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ADJUSTMENT POSSIBILITIES ON COTTON FARMS IN WESTERN FRESNO COUNTY, CALIFORNIA

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Mimeographed Report No. 216 March 1959

ACKNOWLEDGMENTS

This study utilized data collected under the direction of T. R. Hedges for the Giannini Foundation Project: Economics of Adjustment on California Cotton Farms. The authors are appreciative for the access to these data. The data also served as a basis for a Giannini mimeographed publication: Caton, D. D., T. R. Hedges, and W. Neill Schaller, *Farm Adjustments and Earnings Under 1955 Cotton Acreage Allotments*. *5. San Joaquin Valley Westside Cotton Farms, 1953-1955*, Mimeographed Report No. 211, California Agricultural Experiment Station, Giannini Foundation of Agricultural Economics, September 1958. The mimeographed report was concerned with past adjustments while this publication is concerned with present and future adjustments. For this reason the basic data have been treated differently in the two reports.

J. E. Faris
Yair Kadishay

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ADJUSTMENT POSSIBILITIES ON COTTON FARMS IN WESTERN FRESNO COUNTY, CALIFORNIA

by

J. Edwin Faris [1]
Yair Kadishay [2]

INTRODUCTION

Cotton is the most important field crop in California in terms of gross farm income. In 1953, one-fifth--or 1,400,000 acres--of California's irrigated land was planted to cotton. Since 1954 the cotton producers in California (nearly 14,000) have been confronted with production controls, namely, acreage allotments. In 1954, cotton acreage was reduced by approximately one-third from the 1953 acreage (from 1,400,000 acres to 943,000 acres). Cotton acreage in the years 1955 through 1958 has been approximately one-half of the 1953 cotton acreage.

Penalties make it relatively unprofitable to produce more than the allotted acreage which releases land and other resources formerly used in cotton production. As the cotton enterprise made the most profitable use of these resources before the restrictions were imposed, the farmer is faced with the problem of determining the next most profitable use of his available resources. Production controls appear to be more than a temporary measure. Thus, the changes that the cotton producer must make in enterprise organization cannot be considered as a temporary adjustment but an adjustment of prolonged duration.

The objective of this investigation is to determine the optimum enterprise combinations for selected cotton farms under varying conditions with respect to resource availability, yields, and factor and product prices.

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Special consideration is given to changes in cotton acreage allotments, cotton acreage reserve, water availability and the quality of soil.

Farmers are operating in certain physical, economic, and institutional environments. Changes in these environments affect their organization and utilization of resources in any given time period. The most important physical environments are briefly described and discussed in Section I. The organization of cotton farms and the major changes that occurred between 1953 (pre-acreage allotment period) and 1955 (second year of the program) are described in Section II. In Section III the framework of analysis for adjustment opportunities is formulated. The optimum enterprise combinations for representative cotton farms in the area are calculated in Section IV, using certain assumed levels of technology, prices, costs, and resource availability. The possibilities for adjustment and special problems are also discussed in this section. The stability of the optimum enterprise organizations and the implications with respect to changes in net cash returns are presented in Section V. In addition, the effects of optimum organizations of changing acreage allotments are determined in this section. The summary and conclusions are presented in the last section.

I. NATURAL RESOURCES IN WESTERN FRESNO COUNTY

Natural resources place limitations on what farmers can economically produce. The type and/or quantity of land, climate, and water are very important in determining what alternative enterprises farmers consider in their production plans. The purpose of this section is to describe the availability of natural resources in Western Fresno County, an area of approximately 1,410 square miles or 902,150 acres. 1/ Western Fresno County is located in the middle of the San Joaquin Valley and is considered as that part of Fresno County west of the San Joaquin River and the Fresno Slough (Figure 1).

Land and Soils 2/

A uniform relief of gently sloping alluvial fans is characteristic of Western Fresno County. The gentle slope is important in a region where irrigation is a primary requisite for agricultural production.

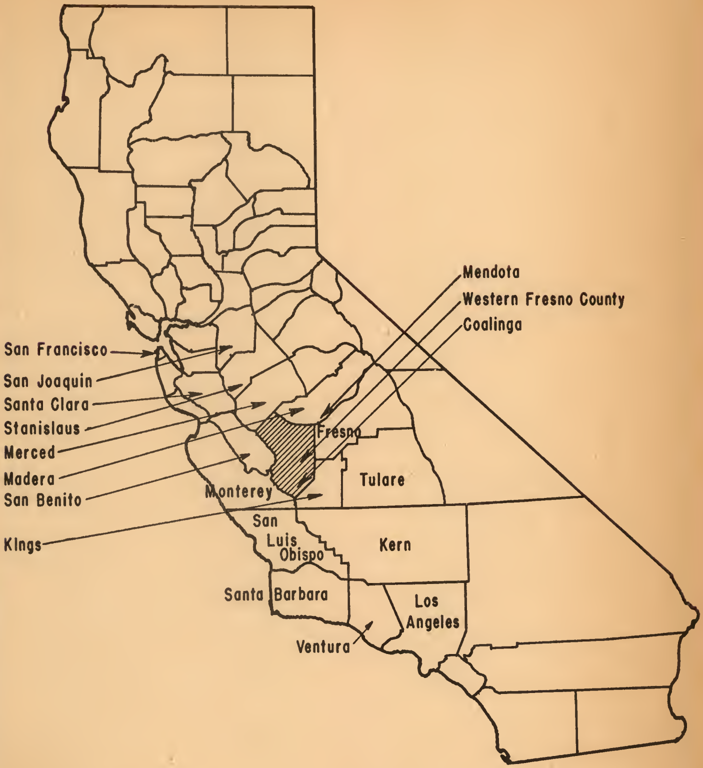
Out of the total area of 902,150 acres, 627,425 acres, or 69.5 per cent, are suitable for intensive agricultural production. Soils are classified according to their production capabilities. The soils suitable for intensive agricultural production are classified as grade I, grade II and grade III soils. The expectation as to yields for most crops are the highest on grade I soils, and the lowest on grade III soils.

Although white alkali is characteristic of much of the land in Western Fresno County, most of the intensive agricultural production is on soils free from alkali or soils classified as slightly alkali. However, a slight amount of alkali in the soil does not markedly reduce the yields of shallow-rooted crops.

1/ The definition of the area is identical with that given by Harradine, Frank F., Soils of Western Fresno County, California (Berkeley, California: August 1950), 85p.

2/ Ibid.

Figure 1. Location of Western Fresno County, California



More than 80 per cent of the land in Western Fresno County has good or excellent surface and subsurface drainage. The remaining area, comprised of basin and semi-basin land, is subject to a periodic high water table. Good drainage is important and necessary to obtain the optimum growing conditions and to prevent the accumulation of alkali in the surface and subsoil.

Climatic Factors

The climatic characteristics of Western Fresno County are similar to the Mediterranean type. The long, hot summersand the mild winters result in a relatively long growing season, which averages 248 days and ranges from 216 days at the Helm Station to 282 days at Panoche Junction (Figure 2). This long growing season is favorable for the production of a large number of field crops in Western Fresno County.

Precipitation provides but a minor part of the water requirement for most crops produced in Western Fresno County. The average annual rainfall is about 7 inches with approximately 90 per cent of the rain falling from November through April (Figure 2). It is estimated that approximately .2 acre foot per irrigated acre can be derived from effective precipitation in the area. 1/ Crops that can be dry farmed in the area, such as barley and wheat, usually need two irrigations before satisfactory yields are obtained.

Water Supply 2/

The major source of irrigation water in Western Fresno County is ground water. Surface water from streams provide only a small portion of irrigation

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1/ See Summers, David S., and J. W. Fink, Panoche Water District Water Supply, Chapter IV, (Fresno, California, December, 1954), 35p., U. S. Department of Agriculture, Bureau of Reclamation.

2/ Most data for this sectionwere obtained from an extensive study on the water conditions in the area made by the staff of the Ground Water Branch of the U. S. Department of Interior, Geological Survey. Davis, G. H., J. P. Poland, et al., Ground-Water Conditions in the Mendota-Huron Area, Fresno and Kings Counties, California, (Sacramento, California, June 1954) 102p.; Prepared in cooperation with the California Division of Water Resources.

[illegible] part of the area in western Fresno County [illegible] [illegible] and [illegible] drainage. [illegible] [illegible] sand, [illegible] major basin. [illegible] is [illegible] and [illegible] [illegible] by [illegible] in [illegible].

Climatic Setting

The climatic characteristics of western Fresno County are typical of [illegible]. [illegible] which averages 200 [illegible] (Figure 7). [illegible] of [illegible] temperatures.

Precipitation [illegible] (Figure 8). [illegible] about 7 inches [illegible] approximately 90 per cent of the [illegible] (Figure 9). [illegible] in the [illegible]. 1/ [illegible] in the [illegible] April.

Water Supply 2/

The major source of irrigation water in western Fresno County is ground water. Surface water from streams [illegible] only a small portion of irrigation

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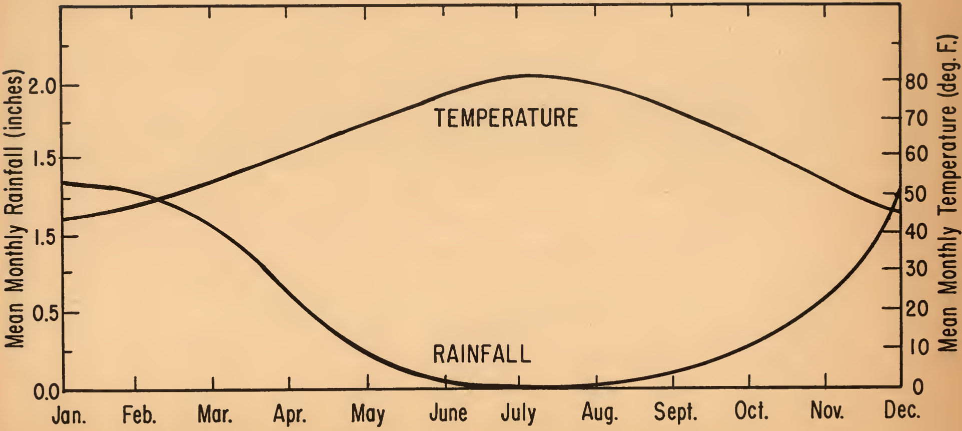
1/ See [illegible], [illegible] Fresno County, California [illegible] 1951, U. S. Department of Agriculture, Bureau of [illegible].

2/ Most data for this section [illegible] study of the water conditions in the area made by the staff of the Ground Water Branch of the U. S. Department of Interior, Geological Survey. Davis, G. H., et al., Ground-water Conditions in the Mendota-Huron Area, Fresno and Kings Counties, California. Sacramento, California, [illegible] 1957. [illegible] in cooperation with the [illegible] of Water Resources.

Figure 2. Mean Monthly Temperature and Rainfall Distribution for Western Fresno County, California



water used in the area. An important exception is the Panoche Water District Area which receives a considerable amount of surface water from the Delta Mendota Water Canal.

Water Supply--Western Fresno County

Fresh water deposits in Western Fresno County extend from the land surface to a depth of a least 3,000 feet below the surface. There are two water bearing zones designated as the upper unit and the lower unit. These units or water bearing zones are separated by impervious diatomaceous blue clay ranging in thickness from 20 to 120 feet. The upper water bearing zone, ranging from the land surface to a depth of 400 to 800 feet, which contains a body of semi-confined ground water, is generally of poor quality. This poor quality water, predominantly calcium and magnesium sulfate water, is usually unsatisfactory as it has a detrimental effect on crop production. 1/

Probably 80 per cent or more of the irrigation water in Western Fresno County is pumped from the lower water bearing zone. This zone, which is 600 to 1,500 feet thick, produces water of a good quality. The average yield of irrigation wells from this zone is 1,100 G.P.M.

The increase in pumping lift.--In 1952 there was approximately one well per square mile in the area. These wells were in operation about 85 per cent of the year as crops are grown throughout the year and fields are irrigated day and night.

Heavy and increasing draft on ground-water supplies has been far in excess of replenishment, and water level in some areas has been declining at a rapid rate since 1945.

1/ An exception is the area along the eastern border southeast of Trinquillity, where water of much better quality is found.

The area of Western Fresno County excluding Pleasant Valley can be divided by the rate of the increase in pumping lift into northern and southern districts. 1/ The northern district has a smaller annual rate of ground-water pumpage than does the southern district. This difference can be attributed to fewer number of wells being drilled in the northern district and to the fact that the northern district enjoys a supply of surface water from the Panoche Water District, whereas the southern district lacks any important supply of surface water. 2/

Pumpage in the northern district almost trebled from the 1935-36 to the 1952-53 agricultural year, whereas pumpage in the southern district increased from 20,000 to 895,000 acre feet, an increase of 4,475 per cent (Figure 3). Pumpage in the two districts was about equal from 1939-40 to 1945-46, but by 1952-53 pumpage in the southern district was almost three times that of the northern district.

The heavy pumping draft has increased the pumping lift in the lower water bearing zone as much as several hundred feet in the past twenty years. As of 1951 the confined water in this zone was moving from the east and the northeast into an elongated pumping depression which extends the full length

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1/ The northern district is that part of the area north of the north line of Township 16, the southern district is the part of the area including Township 16 south, and extending southward to Tulare Lake (Figure 4).

Pleasant Valley has a unique ground-water condition. Five water streams enter the valley and naturally replenish the ground-water resources, thus keeping the pumping lift from increasing at such a rapid rate as either the northern or southern districts.

2/ Although the Panoche Water District is only a fraction of the northern district, the pumpage in this district reflects itself on the average figures for the whole northern area. Between 1941 and 1947, the pumpage in the Panoche Water District averages 26.1 percent of the total pumpage in the northern district, and only 10.3 per cent between 1947 and 1953.

The area of Yellowstone County [illegible] Billings which [illegible] in the [illegible] [illegible] of the [illegible] [illegible] [illegible] [illegible] [illegible] has a [illegible] [illegible] [illegible] [illegible] than [illegible] the southern district. [illegible] [illegible] [illegible] [illegible] [illegible] the fact that the western district enjoys a supply of [illegible] water from the [illegible] River [illegible], whereas the southern district [illegible] [illegible] important irrigation areas. 2/

Changes in the northeastern district [illegible] trebled from the 1930's to the [illegible]. [illegible] changes in the southern district [illegible] from [illegible] to [illegible], an increase of [illegible] per cent (Figure [illegible]). [illegible] in the [illegible] [illegible] from 1930 to [illegible], and in 1950 [illegible] of the southern district was almost twice [illegible] that of the [illegible] [illegible].

The only remaining [illegible] the Yellowstone [illegible] [illegible] [illegible] hundred [illegible] of [illegible] [illegible] since 1920 the [illegible] [illegible] [illegible] [illegible] [illegible]

1/ The western district [illegible] part of the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] at such a rate [illegible] [illegible] [illegible] district.

2/ Although [illegible] [illegible] the [illegible] [illegible] [illegible] between 1940 and 1950, [illegible] [illegible] [illegible] per cent [illegible] 10.3 per cent between 1940 and 1950.

Figure 3. Estimated Ground-Water Pumpage in the Mendota-Huron Area, and Cotton Price Relatives (1940-1944 = 100), Western Fresno County, California

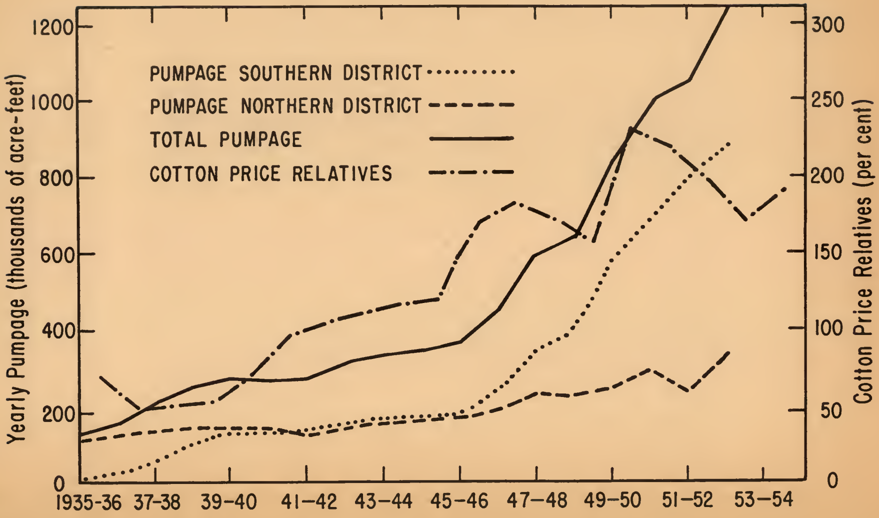
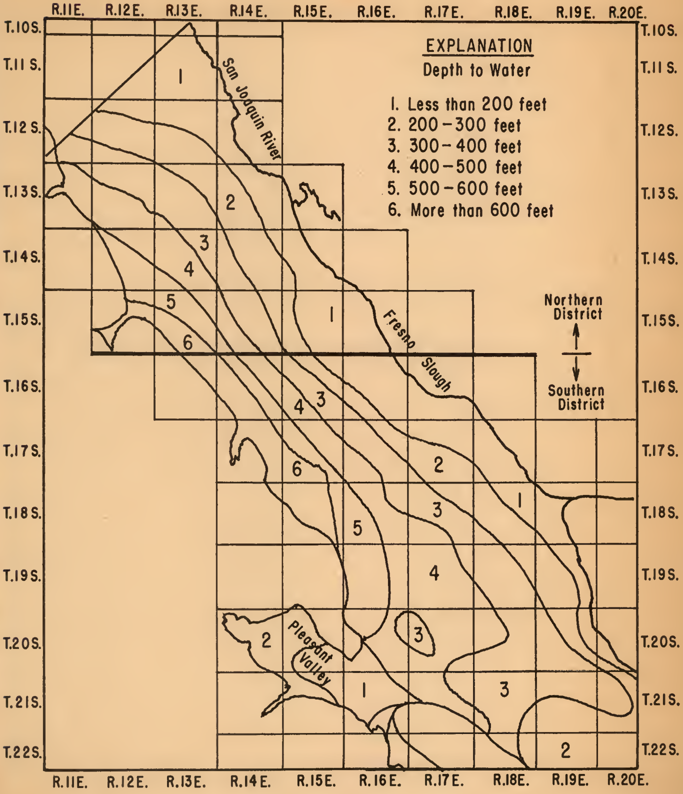


Figure 4. Map Showing Generalized Depth to Pumping Level in Irrigation Wells in 1950-51, in the Mendota-Huron Area, California



of Western Fresno County. Figure 4 clearly shows the general pattern of depth of pumping in the area as of 1950-51 agricultural year. As of this year pumping lift ranged in the area from 100 feet below land surface to more than 700 feet near the mouth of Cantua Creek.

The increase in the pumping lift since the large scale irrigation began during the first World War has ranged from 150 feet near Mendota in the northern district, to roughly 300 feet in the vicinity of Huron in the southern district. Most of the increase has occurred since 1940. Since 1945 the average rate of the annual increase has been 4 to 7 feet in the northern district and 20 to 30 feet in the southern district.

II. COTTON FARMS IN WESTERN FRESNO COUNTY

Adjustment opportunities for cotton farms imply the opportunity for a change from the present organization of these farms. The quantity and quality of land, water, allotments, equipment, and power available are instrumental in determining adjustment opportunities in the short-run. Actually each farm operation has a particular combination of available resources. However, it would be impossible in this investigation to handle each farm separately. Therefore, in this section, typical or representative cotton farms will be constructed for Western Fresno County.

Size of Farm

Large cotton farms are dominant in number and acreage of cropland in Western Fresno County (Table 1). The distribution of cotton farms by acres of cropland shows the largest concentration of farms, 29.3 per cent, in the 801-2,000 acre group in 1953. The second largest concentration, 25.3 per cent of the farms, is in the 2,001-5,000 acre group. These two groups contained approximately 55 per cent of the farms, 31.4 per cent of the cropland, and 37.3 per cent of the cotton allotments in 1954.

The concentration of cropland and cotton production in a relatively small number of farms is clearly revealed by the fact that farms of 5,001 and above acres of cropland, 17.3 per cent of the total number of farms, contained 65.5 per cent of the cropland in 1953 and 57.7 per cent of the cotton acreage alloted to the area in 1954.

It appears that the size of operation is large in this area because of unique conditions of physical and economic environments. Large investments in wells, equipment, and power plus extremely favorable market conditions for agricultural commodities (cotton in particular) since the early 1940's

TABLE 1

Average Acreage and Cotton Acreage in 1953, and Acreage Allotments in 1954 by Farm Size Groups. Western Fresno County, California

	Per cent of total farms	Acres of cropland		Acres of cotton			
						allotments 1954	
Cropland		average	per cent of total cropland	1953 average	1951-1953 average	average	per cent of total cotton
101-400 a/	14.0	220	.8	114	100	78	1.5
401-800	14.0	606	2.3	284	258	178	3.5
801-2,000	29.3	1,248	9.8	438	472	322	13.1
2,001-5,000	25.3	3,193	21.6	982	994	684	24.2
5,001-10,000	11.3	6,871	20.8	1,768	1,706	1,211	19.1
10,000-over	6.0	27,862	44.7	7,468	7,123	4,630	38.6
Total	99.9	--	100.0	--	--	--	100.0

a/ Four farms which had less than 60 acres of cropland were excluded. Their combined area is 117 acres.

Source: Listing Sheets in Fresno County Office of the Agricultural Stabilization and Conservation Committee.

encouraged large size operations. The size of the necessary investments probably restricted entry in this area to those having access to large quantities of capital.

Crop Organization

Figures on crop acreage and value of production are reported for Fresno County as a whole, not for the east or west side of the county separately. Field crops are the major source of agricultural income in Fresno County. Income from field crops accounted for more than 50 percent of the total value of agricultural production between 1953 and 1955 inclusive. 1/ Cotton provides the largest single source of agricultural income in the county. In 1953 Fresno County produced cotton lint, seed, and linters valued at 51.3 per cent of the value of all field crops produced in that year; 43.3 per cent in 1954 and 38.1 per cent in 1955.

Field crops in general and cotton in particular, are considerably more important in the west side of Fresno County because of serious climatic and water limitations which restrict the production of fruits and livestock.

Questionnaire returns in 1954 show that during 1953 and 1954 cotton, barley and fallow land were the major components of the crop rotation with melons and alfalfa seed being produced on some farms. 2/ Interviews with cotton farmers in the area in 1955 confirmed that the major crops had not changed.

1/ Agricultural Commissioner's Annual Report, 1953-1955, Fresno County, Department of Agriculture, Fresno, California.

2/ Caton, D. D., T. R. Hedges, and W. Neill Schaller, Farm Adjustments and Earnings Under 1955 Cotton Acreage Allotments. 5. San Joaquin Valley Westside Cotton Farms, 1953-1955, Calif. Agr. Exp. Sta., Giannini Foundation of Agricultural Economics, Mimeo. Reports Nos. 211, 212, September, 1958.

The above sources of information show a variety of crop organizations in the period 1953-1955. The most common of these were:

a) Cotton, barley, fallow land.

b) Cotton, barley, melons, and fallow land.

c) Cotton, barley, sugar beets, and fallow land.

d) Cotton, barley, alfalfa seed, milo and fallow land.

Changes in Crop Organization

Cotton acreage allotments and marketing quotas imposed since 1954 have resulted in a change in crop organization in the area. Farmers were faced with the problem of determining the best alternative use for land released from cotton production by the control program. A penalty of 50 per cent of the parity price for cotton produced on land in excess of the allotment insures rather strict conformity to the acreage allotment.

As a result of these controls the average reduction in cotton acreage for producers in Western Fresno County was approximately 45 per cent between 1953 and 1956 (Table 2). This decrease in acreage allotments resulted in approximately 42,000 acres of land being taken out of cotton production between 1953 and 1956. 1/

The most immediate and predominate response was to fallow the diverted land. The shift to barley production was second only to that of fallowing. By 1955 more alternative lines of response were evident. Data on changes in Fresno County as a whole are indicative of these responses in Western Fresno County. The changes indicated in Table 2 coincide very well with the data on changes obtained from questionnaires, farmer interviews, and people associated with the agricultural industry in Western Fresno County.

1/ There was very little difference between size of the 1956 and 1958 cotton allotments. The national cotton allotments in 1956 and 1958 were 17,391,000 acres and 17,400,000 acres, respectively.

TABLE 2

Acreage of Field Crops in Fresno County, California
1946-1956

Year	Alfalfa seed	Melons	Barley	Cotton	Corn	Flax	Sugar beets	Wheat	Grain sorghum	Safflower
1946	---	17,340	145,000	85,000	500	19,220	2,500	39,000	5,000	
1947	---	18,010	130,000	138,600	300	33,000	2,700	45,000	4,200	
1948	---	16,896	276,600	273,000	400	36,000	2,500	43,000	4,460	
1949	925	3,665	331,920	260,200	---	22,056	2,750	45,000	5,020	
1950	6,280	---	449,881	158,200	9,300	---	250	56,609	8,000	6,714
1951	8,228	11,824	445,383	334,500	1,600	---	406	53,839	1,200	3,900
1952	6,406	14,782	489,921	358,000	---	---	900	26,919	2,400	3,200
1953	15,656	15,169	464,550	350,000	---	---	3,465	24,700	400	617
1954	19,914	22,687	497,069	235,000	3,998	---	10,924	17,346	17,987[a]	160
1955	34,304	23,065	507,010	192,135	45,000[a]	465	5,721	16,662	60,000[a]	410
1956	48,282	26,282	478,005	190,732	55,000[a]	---	6,937	13,609	49,950[a]	380

[a] Probably this increase in production was primarily on the east side of Fresno County.

Source: Fresno County Agricultural Commissioner, Agricultural Commissioner's Annual Report, 1953-1956, Fresno County, Department of Agriculture, Fresno, California.

In Western Fresno County the tendency appears to have been to shift the acres released from cotton to the production of alfalfa seed, melons, milo, barley, fallow, and sugar beets. 1/

Representative Cotton Farms in Western Fresno County

As mentioned earlier in this section each farm operation is a special case as it has a particular bundle of available resources. However, because of the restrictions on time, money, and available information only two or three representative size farms can be constructed and analyzed.

The data from a complete enumeration of the cotton farms in Western Fresno County (Table 1) reveals that the largest concentration of farms is in two major groups; one group which averaged about two sections of land, and one which averaged approximately five sections of land. 2/ Farms having cropland of less than one section were relatively unimportant in terms of total cropland, total acreage of cotton allotment, and number of farms. Farms having over 5,000 acres of cropland, though most important in terms of their share of total cropland and cotton acreage, are not sufficiently homogeneous to be considered as a group. Some lease portions of their land or are corporate

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1/ Sugar beet production is restricted under the Sugar Act of 1948, as amended. The significance of the present sugar program to cotton farmers is that producers have to conform to acreage (or production) allotments, known as "production share". For farmers which have not established a production history and wishing to do so, the process is slow and the possibilities are limited. To insure conformity with the program benefit payments to growers are made only upon compliance with the acreage restrictions, standard wages and fair prices, as determined by the Secretary of Agriculture.

A complete discussion of the present sugar program may be found in The Sugar Act of 1948, (80th Congress, 1st session, House Report No. 796) and the Extension of The Sugar Act of 1948, (84th Congress, 2nd session, Senate Report No. 1461, January, 1956).

2/ The same concentration of farms was observed in the data obtained from questionnaire returns in 1954. Comparison with data on Western San Joaquin Valley as a whole confirms the findings.

in western Fresno County the marked [illegible] has been to shift the acres released from cotton to the production of alfalfa seed, barley, milo, barley, flax, and sugar beets. 1/

Supplemental Irrigation Farms - Western Fresno County

As mentioned earlier, in this section each farm operation is a special case as it has a particular source of available resources. However, because of the limitations in time, money, and available information, [illegible] three representative illustrations can be considered [illegible].

The data from a complete enumeration of the cotton farms in western Fresno County (Table 11) reveals that the largest concentration of farms is in the middle category, the group which averaged about [illegible] of land, and the group [illegible] approximately five [illegible] of land. 2/ [illegible] of land. [illegible] of [illegible] the drainage, [illegible], and [illegible]. [illegible] though [illegible] in terms of their [illegible] and cotton acreage, are not [illegible] to be considered as typical. [illegible]

1/ These were controlled by restrictions under the Sugar Act of 1948, as amended. [illegible]

A complete description of the present sugar program may be found in The Sugar Act of 1948, [illegible] Congress, 1st session, House Report No. [illegible], and the Extension of the Sugar Act of 1948, [illegible] Congress, 2nd session, Senate Report [illegible], January, 1951.

2/ The [illegible] of farms [illegible] in 1950. Comparison with data [illegible] San Joaquin Valley as a whole confirms the findings.

farms, while others are believed to be linear multiples of the two or five section farms. 1/

Thus, only the two section and the five section farm size group were selected to serve as models for analysis. 2/ The first group will be designated as the two section cotton farms and the latter as the five section cotton farms. A typical or representative farm was constructed from each of these size groups using the physical and economic characteristics of each group.

After representative size farms were selected more specific data were needed to define the most common size-type farm organizations in the area. Some of these data were obtained from a stratified random sample of cotton in Western Fresno County farms. Additional information on physical resource availability and appropriate investments were compiled, summarized and tabulated. These data, together with the data on farm organization, production practices, water problems, and crop yields will be utilized in constructing the framework for the analysis.

1/ In this instance, where the type of farming in general is the same for all farms considered, the use of acreage of cropland as a measure of farm size is justified. In comparing farms producing different types of crops (i.e., dry farming or range livestock production vs. intensive production of strawberries or dry-lot dairy operation), measuring size of farms by acreage is unsatisfactory and misleading.

2/ The choice of a multiple of sections of land for the purpose of the analysis may be also justified on another ground. In studying the farm organizations in Western Fresno County it was learned that in planning production programs, a section of land is usually considered as the basic planning unit. The choice of the section is based on the common practice of drilling one well per section of land. In order to economically justify a heavy investment in drilling a well and establishing an irrigation system, it is thought that a crop rotation should be established on at least an area of one section.

III. FRAMEWORK OF ANALYSIS FOR ADJUSTMENT OPPORTUNITIES

In any problem of maximizing net returns for a firm there are three types of questions to be answered. 1/ These are: (1) how to produce; (2) how much to produce; and (3) what to produce. In this investigation the emphasis is on how much and what to produce. How to produce (the technical coefficients of production) are taken as "given". To determine optimum enterprise combinations and levels of production, it is also necessary to make certain assumptions with respect to resource availability, factor costs and product prices. Thus, the optimum combination of enterprises is defined as that combination of enterprises that would maximize net returns with respect to specified resources, technical coefficients of production and prices.

Technique of Analysis

The research technique employed to determine the most profitable combination of enterprises is that of linear programming. Linear programming is a mathematical technique designed for problems of maximization or minimization of functions subject to constraints in the form of linear inequalities. 2/ The solution is valid under the assumptions of: (1) accuracy of technical coefficients regarding input-output relationships and their assumed linear relation; (2) product and factor prices; and (3) the restraints as to resource availability. However, the use of linear programming to determine adjustment opportunities, in addition to selecting an optimum program, also permits an analysis to be made as to the limits within which the solution will hold by varying the assumptions noted above. The comparative

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1/ It is assumed throughout this study, unless otherwise stated, that the sole objective of the entrepreneur (farmer) is the maximization of monetary returns.

2/ A comprehensive discussion of the linear programming technique and its implications to the theory of the firm can be found in Dorfman, Robert, Application of Linear Programming to the Theory of the Firm, University of California, Berkeley and Los Angeles, 1951.

ease with which this may be done gives it a distinct advantage over the so-called budget approach for these purposes.

Assumptions with Regard to Resource Availability and Technical Coefficients of Production

The description of the natural and other physical resources in Western Fresno County helps provide a basis for specifying a framework of analysis. In the framework of analysis assumptions must be made with respect to resource availability, product and factor prices, and input-output relationships. These basic assumptions form a theoretical model within which the optimum enterprise combinations are selected. These optima, however, are valid only for the specified assumptions and as the assumptions are changed or are invalid the optima also may change.

The typical firm in Western Fresno County controls a group of resources capable of producing alternative products. These resources are land, motive power, farm equipment, an irrigation system, farm buildings, and a farm operator performing the functions of management. In addition, the farm operator has control over liquid capital funds through borrowing or savings. Within a production period the former type of resources are usually considered as fixed. If these resources are assumed to be fixed, then the liquid capital funds can only be used for those inputs consumed within a production period, i.e., labor, gas, fertilizers, insecticides, etc. However, many types of resources may place limits on the optimum combination of enterprises. The resources that may become limiting are determined by the basic assumptions that are formulated.

Resource Availability and Resource Restrictions

The two representative size-type farms in the area, described in Section II, present the basic sets of fixed resources at the disposal of the farm operators in a given time period. They do not explicitly specify any resource

restrictions on production possibilities. Thus, certain realistic conditions or constraints need to be specified. These conditions and constraints can be classified as physical, institutional, and temporal.

Conventionally one limitation on economic activity arises from the increasing costs of inputs or resources as output is expanded beyond a certain point. In linear programming the supply of a limiting resource is conceived as horizontal curve having an absolute limit at a certain point. 1/ This is a problem of opportunity cost where prices play a secondary role.

Assumptions concerning physical, institutional, and temporal restrictions are presented in the following part of this section.

Production period.--The production period of one year is assumed to be independent of any other production period. This study is concerned with the short-run planning period.

Land.--It is assumed that the farm with two sections of land has 4 per cent of the land or 55 acres in roads, fences, ditches, farmstead, and uncultivated land. The five section farm is assumed to have 3 per cent or 100 acres of its land in roads, fences, etc.

Production per acre for various crops is assumed to be a function of the grade or productivity of the soil. Some farms in the area have three grades of soil suitable for intensive agriculture while others have only one or two grades of soil suitable for intensive production. Therefore, it was decided to consider farm operations with only one soil grade, with two soil grades, and with all three soil grades. It is assumed that all of the soil, on the farm with only one grade of soil, is soil grade I (Table 3). The

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1/ A limitation may also be a downward sloping demand curve. However, this possibility is excluded since the assumption of pure competition is made in a later part of this section.

farm with two grades of soil has only soil grade I and II. 1/ On the farm with three grades of soil the proportions of each soil grade are the same as those that prevail in the area as a whole (see Section I).

Water supply.--The supply of irrigation water is one of the most important and restricting resources in Western Fresno County. Nine periods of time are assumed to be the most critical (Table 4). These are the months March through August. The latter three months, which appear to be more critical, in terms of the total quantity available and use by the cotton enterprise, are each divided into two periods. It is assumed that there is one well per section or two wells on the two section farm and five wells on the five section farm. All wells assumed to have the same size and capacity regardless of the size of the farm.

Restrictions on cotton production.--Fifty-six per cent of the three year average (1951-1953) cotton acreage on the two and five section farms is assumed to be the cotton acreage allotted to the individual firm. 2/ The three year average cotton acreage was 33.3 per cent of the total cropland on the two section farm and 31.0 per cent on the five section farm. However, since changes in acreage allotment is one of the variations in restrictions to be tested in later sections, and since the difference is so small, an acreage allotment of 33.3 per cent of the total cropland has been selected for both farms. Thus, 238 and 596 acres are assumed to be the basic cotton acreage allotted to the two and the five section farms, respectively.

1/ The proportion that each soil grade is of the total land in the farm is the same proportion that actually exists between these two soils in Western Fresno County.

2/ This is the average per cent of cotton acreage allotted in 1956 in Western Fresno County.

TABLE 3

Acres of Cropland by Soil Grade, Representative Farms, Western Fresno County, California

Soil grade combinations	Two section farms				Five section farms			
	soil grade I	soil grade II	soil grade III	total	soil grade I	soil grade II	soil grade III	total
	acres							
Farm with:								
One grade of soil	1,230	0	0	1,230	3,120	0	0	3,100
Two grades of soil	915	315	0	1,230	2,306	794	0	3,100
Three grades of soil	750	258	222	1,230	1,891	651	558	3,100

TABLE 4

Supply of Irrigation Water During Critical Time Periods, Representative Farms, Western Fresno County, California[a]

Time periods	Output per well		Supply per time period (ac. in.)	
	assumed discharge (g.p.m.)	acre feet per day	two section farm b/	five section farm c/
3/1 - 3/31	1,200	5.34	3,984	9,960
4/1 - 4/30	1,200	5.34	3,840	9,600
5/1 - 5/31	1,100	4.88	3,624	9,060
6/1 - 6/15	1,100	4.88	1,752	4,380
6/16- 6/30	1,000	4.44	1,608	4,020
7/1 - 7/15	1,000	4.44	1,608	4,020
7/16- 7/31	900	4.00	1,536	3,840
8/1 - 8/15	900	4.00	1,440	3,600
8/16- 8/31	900	4.00	1,536	3,840

a/ It is assumed that water is pumped 24 hours per day.

b/ Two wells supply water to the two section farm.

c/ Five wells supply water to the five section farm.

According to the Soil Bank Act of 1956, cotton producers were not permitted to place more than 30 per cent of their cotton allotment in the cotton acreage reserve program during the 1957 crop year unless the acres of cotton acreage reserve allocated to the County were in excess of that required to cover all agreements. If this situation existed the farmers were permitted to place additional acres in the reserve program. The agreements to participate in the program for Fresno County required less than 50 per cent of the funds allocated to the County for the cotton acreage reserve program in 1957. Therefore, it was assumed for the purposes of this investigation that farm operators could place a maximum of 50 per cent of their cotton allotment in the reserve program. Thus the maximum cotton acreage that can be reserved as a part of a production program is 119 acres on the small farm, and 298 acres on the large one. Payments are fifteen cents per pound of lint payable to the individual farmer on the basis of an estimated average yield established by the County Agricultural Stabilization and Conservation Committee in the area. 1/ Initially it is assumed that the estimated average yield is 1,125 pounds of lint per acre. This assumption is based upon future expectations with respect to yields.

Melons.--Melons will be introduced in several of the programs. Many of the farm operators produce one or more specialty crops such as sugar beets, certified seed or melons. Therefore, the melon enterprise will be used to represent this group of so-called specialty crops.

Availability of other resources.--Labor, motive power, and capital equipment funds are assumed to have no restricting effects on production. There is no limitation on managerial capacity and all labor required is assumed to be available at the market price. A perfectly elastic supply of operating

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1/ The Soil Bank--Objectives, Administration in 1956, U. S. Department of Agriculture, (Washington, D. C., June 1956), 14p.

capital is available at an interest rate of 5 per cent for the two section farm and 4.5 per cent for the five section farm. Motive power, although physically limited on the farm is assumed to be available in the market under contractual or rental basis without any limitations. The effect of timing of the contractual operations was not considered in this analysis. However, it is realized that timing of the operations has a decided effect upon yields.

Technical Coefficients of Production

Information on technical coefficients of production were obtained from interviews with farmers in the area, Experiment Station publications, enterprise sheets constructed by the farm advisors, and personal interviews with specialists on the Davis Campus, University of California. 1/ This information was synthesized into "standards" which represent a set of typical techniques of production used by the better farmers in Western Fresno County or techniques recommended by the specialists for the area. These point estimates portray linear and homogeneous production functions with fixed coefficients of production which conform to the assumptions of the linear programming model regarding production processes.

Standards of input-output relationships (processes) for the representative farms and calendars of operations were constructed on a per acre basis for three levels of output associated with the three soil grades suitable for agricultural production in Western Fresno County. Yields by grade of soil for the various alternative crops considered are presented in Table 5.

1/ Hedges, op. cit., p. 14.

TABLE 5

Assumed Yields by Grade of Soil, Representative Farms, Western Fresno County, California a/

Crops	Units	Grade of soil soil grade I	 soil grade II	 soil grade III
Alfalfa hay	ton	7.5	6.25	b/
Alfalfa seed	pound	750	550	300
Barley	cwt.	33	25	20
Castor beans	cwt.	25	20	17
Field corn	cwt.	50	45	40
Cotton	pound	1,125	875	b/
Cotton acreage reserve	pound	875	625	b/
Flax	cwt.	35	27	18
Melons	crate	175	165	140
Milo	cwt.	50	45	40
Safflower	cwt.	25	20	16

a/ It is assumed that the yields are identical on the two section and the five section farms.

b/ Not considered as a production possibility.

The level of technology and practices are considered to be the same and kept constant on both size farms, and on the three soil types. [1] Inputs, however, differ between the two models because of different rate of performance, and the more extensive use of contractual arrangements on two section farms. [2] The differences in inputs is attributed to the scale of operation and more extensive contractual arrangements is a matter of a common practice in the area for certain equipment. The larger inputs of tractor hour and labor on the five section farms are due to the additional harvesting operations performed by their own equipment. Where there is only a small difference in inputs between the two size farms, it is usually due to a somewhat larger equipment with better rates of performance at the disposal of the latter. Differences in technical coefficients of production among soil grades is primarily due to the harvesting of different quantities of output.

Assumptions with Regard to Factor and Product Prices

In forming price and cost expectations, "normal" price relationships were sought. Past price and cost relationships were used as the basis for forming these expectations. Trends, government programs, personal opinion and the opinions of representatives of the agricultural industry in California were also taken into consideration. Certain assumptions were made regarding the future. Among these were the following: (a) government production controls are here to stay, and (b) present levels of income, income distribution, employment and technology are assumed to remain the same. Present individual consumption preferences, and present world conditions assumed to prevail in

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[1] This implies that land preparation, number of cultivations, level of fertilization, rate of seeding, pest and disease control are the same on the small and large farms and on the different soil types. Such an assumption is necessary because of lack of technical data regarding variations in inputs and outputs with change in soil types.

[2] The data show that among small cotton farms in the area there is a greater tendency to contract most of the harvesting operations, and operations requiring expensive equipment, than on the large farms.

The labor techniques and practices are considered to be the same [illegible] on both the large and the small soil types. 1/ Inputs, however, differ between the two soils because of different use of pesticides, and the more extensive use of contractual arrangements on the smaller farms. 2/ The differences in inputs is attributed to the scale of operation and more extensive contractual arrangements [illegible] of a common [illegible] equipment. The larger amount of tractor hours and labor on the [illegible] farms are due to the additional labor time operations performed by their own equipment. While there is only a small difference in input between the two size farms, it is usually due to a [illegible] and larger equipment with better rates of performance; the benefit of the latter. Differences in technical coefficients of production among soil groups is generally due to the interaction of different yearly rates of inputs.

[illegible] with [illegible] Prices and Present Prices

In [illegible] "normal" price relationships were sought. Such price and cost relationships were used as the basis for [illegible] expectations. Trends, government programs, economic conditions and the judgment of representatives of the agricultural industry in California were [illegible] consideration. Certain assumptions were made regarding the future. Among these were the following: (1) government programs [illegible]; and (2) present levels of income, income distribution, employment and technology are assumed to remain the same, present [illegible] and present [illegible] conditions assumed to prevail [illegible]

1/ This implies that land preparation, manner of cultivation, level of fertilization, rate of seeding, pest and disease control are the same on the small and large farms and on the different soil types. Such an assumption is necessary because of lack of technical data regarding variations in levels and inputs with changes in soil types.

2/ The data show that among small cotton farms in the same area there is greater tendency to contract much of the production operations, and operations requiring expensive equipment, than on the large farms.

the future. Furthermore, it is assumed that the individual firm is operating in a perfectly competitive market. That is, the firm can sell all its output at the market price without affecting the market price. Also the firm faces a perfectly elastic supply in purchasing its productive services. The supply function of limiting resources is assumed to be infinitely elastic up to the limiting quantity where it becomes infinitely inelastic. Subjective certainty regarding factor costs and product prices is assumed throughout the study.

Product Prices

The present price support of $ .32 per pound of cotton lint was chosen as the expected average annual price. This is approximately the 1946-1955 average annual price for cotton lint. Average annual prices, 1946-1955, served as price expectations for melons (midsummer cantaloupes) and sugar beets. These prices are $3.10 per 80 pound crate of melons, and $13.70 per ton of sugar beets. 1/ Prices for oil seeds were based on the average annual price ratios 1946-1955. These price ratios reflect intricate interrelationships among the value of the oil extracted from the seeds, the pomance that they yield, the supply and demand of the products, the feeding value of the meals (or in some cases their value as fertilizers), and the degree of direct and indirect substitutability as oil products or feed products. 2/ A price of $3.40 per bushel for flaxseed was used as a base price for determining the price of other oil seeds. 3/ Thus, relative to flaxseed the expected price for cotton seed is $55.00 per ton, and for safflower $72.00 per

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1/ The price of sugar beets includes program payments.

2/ By indirect substitutability it meant a substitution between two products by means of a third media. An example is a substitution of linseed oil, which is an unedible oil, for cotton seed oil, which is an edible oil, by means of safflower oil, which is a dual purpose oil.

3/ A price of $3.40 per bushel of flaxseed is slightly lower than the 1956 average annual price support for California, and slightly higher than the 1954 and 1955 prices.

ton. 1/ Seven cents per pound of castor beans was chosen after consulting with the representative of the industry in California. 2/

The average annual price ratios, 1946-1955, were used as a basis in forming price expectations for feed grains and alfalfa hay. These price ratios presumably reflect the feeding value of these crops. A bench price of \$3.00 per hundredweight of corn was selected. Consequently, the prices of the rest of the feed grain were determined to be as follows: \$2.50 per hundredweight of barley, \$2.55 per hundredweight of milo, and \$23.00 per ton of alfalfa hay. The expected average annual price of alfalfa seed was determined to be \$ .28 per pound, which is one cent lower than the 1946-1955 average price. This reduction in price was assumed because of the large expansion in alfalfa seed production since 1954.

Factor Costs

As previously stated, the objective in forming factor price expectations was to select a set of average annual factor price figures representing "normal" price relationships. The Index of Prices Paid by Farmers, reveals a relatively high level of prices paid since 1948, with a slight upward trend. However, the prices paid during the last three years, 1953-1955, though relatively high, show considerable stability. Due to this stability average prices paid by farmers during 1955 were selected as the "normal" costs for the near future.

1/ The price situation of safflower and castor beans was discussed with Mr. Carl F. Classen, the representative of Pacific Vegetable Oil Corporation, Woodland, California. These are two products with a unique price structure. They are both supported and their production encouraged by the industry and the government. In spite of the declining trend in safflower prices, the industry believes that the new varieties containing higher per cent of oil, and the price support program will enable the industry to pay an average price above \$70.00 per ton over the next several years.

2/ Ibid.

Additional information on prices paid was obtained from many sources in Western Fresno County. Prices were secured concerning the rate of payment to labor, payment for equipment rentals, and contracted and piece work. The present prices of supplies, power costs, real estate items, and prevailing rates of interest also were collected and used. 1/

Processes Considered as Possible Alternatives

A realistic solution for the problem of alternative optimum adjustments requires the consideration of as many alternative lines of action as possible. Therefore, in addition to the enterprises (processes) commonly grown in the area such as cotton, barley, alfalfa seed, and melons, a group of less common enterprises was investigated as possible alternatives for the released cotton acreage. These were flaxseed, castor beans, field corn, milo, safflower, sugar beets, and alfalfa hay. Livestock production does not appear to be a very promising alternative as an integrated enterprise with crop production in the area. However, some large scale specialized beef feeding operations are in the area. To test the hypothesis regarding the production of livestock, alfalfa hay was added to the list of alternatives. It is believed that if alfalfa hay enters the optimum program, which means that it will be profitable to produce it as a cash crop, livestock enterprise might be integrated with crop production. Last but not least, the cotton acreage reserve program was assumed to be a possible alternative.

1/ Hedges, op. cit., p. 14.

Enterprise Budgets

An enterprise budget was constructed for each alternative crop considered. 1/

In constructing the budgets only the cost of inputs that vary with the level of output were included. That is, only cash expenses plus interest on operating capital. Costs that do not vary with output (fixed costs) were not included in the budgets. These fixed costs do not affect the decisions concerned in this study, namely, what to produce and how much. However, such costs (e.g., all interest charges and depreciation) should be included whenever additional investments are considered in the planning stage.

The net cash return as used in the budgets is defined as the difference between the gross receipts from the sale of the product produced by a process minus the total variable cost incurred in producing the level of that process. One acre was used as a unit process level for all enterprises considered in this study. This was possible because all alternative processes considered were field crops.

Budgets were constructed for each of the alternative possibilities considered by size of farm and soil type, a total of 72 budgets. The net cash returns derived from the budgets are presented in Table 6.

1/ An enterprise budget (on a per acre basis), as employed in this study is defined as:

$$\sum_{i=1}^{l} Q_{ik}P_{ik} - \sum_{j=1}^{n} V_{jk}P_{jk} = \text{net cash return}$$

where: Q_{ik} = the quantity of the i^{th} salable product yielded by a unit level of process k.

P_{ik} = the price of the i^{th} product yielded by a unit level of process k.

V_{jk} = the quantity of the j^{th} variable input used in process k.

P_{jk} = the price of the j^{th} input used in process k.

TABLE 6

Net Cash Returns by Grade of Soil for Processes Considered as Possible Alternatives, Representative Farms, Western Fresno County, California a/

Alternative crops	Net cash returns on two section farms for crops on: (dollars)			Net cash returns on five section farms for crops on: (dollars)		
	soil grade I	soil grade II	soil grade III	soil grade I	soil grade II	soil grade III
Alfalfa hay	45.79	24.02	b/	48.98	27.15	b/
Alfalfa seed	67.50	19.03	c/	70.06	21.58	c/
Barley	40.76	21.86	9.55	46.70	27.33	15.25
Castor beans	56.42	27.32	9.86	58.96	29.86	12.40
Field corn	47.43	35.38	23.32	48.23	36.18	24.12
Cotton	244.92	164.93	b/	254.51	173.73	b/
Cotton acreage reserve	127.68	90.18	b/	131.25	93.75	b/
Flax	39.82	15.07	c/	46.33	20.01	c/
Melons	118.52	105.02	71.27	121.15	107.65	73.90
Milo	73.98	61.92	49.86	81.69	69.44	57.17
Safflower	25.46	8.28	c/	31.92	14.35	.35
Sugar beets	191.33	127.33	101.73	193.13	129.13	103.53

a/ The net cash returns presented in this table were determined by subtracting the variable costs of production from the gross returns. Consequently, they are different from the net returns presented in: Caton, D. D., T. R. Hedges, and W. Neill Schaller, Farm Adjustments and Earnings Under 1955 Cotton Acreage Allotments. No. 5. San Joaquin Valley Westside Cotton Farms, 1953-1955, Calif. Agr. Exp. Sta., Giannini Foundation of Agricultural Economics, Mimeo. Report No. 211, September 1958.

b/ Not considered as a production possibility.

c/ Negative net cash return.

Criteria Used in Selecting Processes

Under the conditions previously specified there are two basic criteria for determining which alternatives will be considered as possible for the optimum production program. These are net cash returns and the amount of the restricting resources used by each process. These two criteria can be expressed for each process in terms of the per cent of resources used per unit of net cash return. This was done for all the alternatives for the two section farm and the five section farm using $100 as the unit of net cash return. It is obvious that a process which uses more of all the limiting resources per unit of net return than another process is inefficient. Using this procedure it was possible to eliminate a number of processes, e.g., alfalfa hay, which were obviously inefficient.

It is also possible to determine those resources which are not limitational by using the same general procedure. For example, water requirements for all production processes during the month of May is equal or less than that required during the first half of June. Thus the supply of irrigation water during May does not impose any limitations on the production program, since the supply of water during the first half of June will always be more of a limitation on production. Expressing processes in terms of the per cent of resources used per unit of net cash returns enables the researcher to eliminate inefficient processes and nonlimiting resources by inspection and thus to reduce the actual calculations considerably. 1/

1/ A complete discussion of the procedure and its implications can be found in Boles, James N., "Short Cuts in Programming Computations," Journal of Farm Economics, Vol. 38, No. 4, November, 1956, p. 981.

In this particular study it was possible to reduce the number of processes to be included in the calculations from 32 to 20, and the number of resources from 15 to 12.

IV. OPTIMUM ENTERPRISE ORGANIZATIONS AND RESOURCE UTILIZATION

The determination of optimum farm organizations and resource utilization under certain specified assumptions and conditions is presented in this section. Several different possibilities with respect to resource limitations and production alternatives available on cotton farms in Western Fresno County are examined and optimum adjustments determined for each possibility.

The same general procedure is followed in analyzing the two section and five section farms. In each farm size group there is a standard farm with four different production alternatives available. They are as follows: 1/

S. Standard farm--farm with a cotton allotment only.

M. Standard farm--plus the melon enterprise. 2/

R. Standard farm--plus the cotton acreage reserve enterprise.

MR. Standard farm--plus the melon enterprise and the cotton acreage reserve enterprise.

In addition, assumptions with respect to the quality of the land resources are varied for each of the above farms. An analysis of the effects of changes in soil grade on the optimum enterprise organization and resource utilization will be made for each of the above alternatives.

For each of the four basic farms there are three possible combinations of soil grades which are as follows: 3/

1/ The letters, "S", "M", "R" and "MR" will be used to indicate the alternatives faced by the farms.
All other crops which were considered as suitable for production in the area, with the exception of specialty crops, are assumed to be available as alternatives for production on all farms.

2/ The melon enterprise was selected as the specialty crop to be included as a production possibility in order to examine the effects of specialty crops on optimum farm organizations.

3/ The combination of soil grades will be referred to in many instances by using the capital letter preceding each combination of soil grades.

1. Farms having only soil grade I.

2. Farms having a combination of soil grades I and II.

3. Farms having a combination of soil grades I, II, and III.

This results in a total of 24 optimum farm organizations, 12 in each size group.

Two Section Farms

The resources available to the two section farms are described in Sections II and III. Certain of these resources are assumed to be restricting (they may limit production). These restricting resources are the quantity and quality of land, a seasonal distribution of irrigation water, and certain production opportunities which are institutionally limited.

Optimum Organizations for Farms with One Grade of Soil

The optimum farm organizations and patterns of resource utilization for the four basic farms with one grade of soil are presented first. Each farm is assumed to have 1,230 acres of grade I soil available for crop production.

Optimum organization for the standard farm (2-1-S) 1/.--The standard optimum enterprise combination and resource utilization of the two section farm on grade I soil is presented in Table 7. It consists of 674 acres of barley, 70 acres of milo, 238 acres of cotton, and 248 acres of idle land. This optimum organization results in a net cash return of $90,940. The month of March and the first half of July are the restrictive periods of water supply, that is, periods during which the supply of water imposes a restriction

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1/ The labeling of the farms includes three parts, the first number stands for the size of the farm, in this case 2 stands for the two section farm. The second number stands for the soil grade combination. In this instance 1 indicates that the farm has only soil grade I. The last letter, "S", indicates the alternative faced by the farm which in this instance is the standard farm with a cotton allotment only.

TABLE 7

Optimum Farm Organization and Resource Utilization, Two Section Farm (2-1-S) and (2-1-R) on Soil Grade I, Western Fresno County, California

Resources			Enterprise organization			Unused resources	Value of the marginal unit of resource a/	Total net cash return
item	unit	quantity available	cotton	barley	milo			
Soil grade I	acre	1,230	238	674	70	248	.00	
Irrigation water								
3/1 - 3/31	acre inch	3,984	952	3,032	0	0	9.00	
4/1 - 4/30	acre inch	3,840	0	3,032	0	808	.00	
5/1 - 5/31	acre inch	3,624	595	0	350	2,679	.00	
6/1 - 6/15	acre inch	1,752	595	0	196	961	.00	
6/16- 6/30	acre inch	1,608	1,190	0	210	208	.00	
7/1 - 7/15	acre inch	1,608	1,190	0	418	0	12.30	
7/16- 7/31	acre inch	1,536	1,190	0	210	136	.00	
8/1 - 8/15	acre inch	1,440	1,190	0	210	40	.00	
Cotton allotment	acre	238	238	0	0	0	147.00	
Cotton acreage reserve	acre	119	0	0	0	119	.00	
Net cash return	dollar	---	58,290	27,470	5,180	---	---	90,940

a/ These are read as $9.00 per acre inch of water or $147.00 per acre of cotton allotment.

on production. The marginal value productivities of water are \$9.06 and \$12.33 per acre inch, respectively.[1] Cotton acreage allotment, also a limitational resource in this program, has a marginal value productivity of \$147.00 per acre.

Optimum organization for the standard farm plus the melon enterprise (2-1-M).--When the melon enterprise is available as a production possibility the optimum organization includes 42 acres of alfalfa seed and 76 acres of melons in place of the 70 acres of milo (Table 8). The net cash returns are increased by \$6,670 and the supply of irrigation water in the last half of June is an additional restricting resource.

Optimum organization for the standard farm plus the cotton acreage reserve enterprise (2-1-R).--This optimum organization is identical with that of the standard farm because the cotton acreage reserve enterprise does not enter into the optimum organization (Table 7).

Optimum organization for the standard farm plus the melon enterprise and the cotton acreage reserve enterprise (2-1-MR).--The addition of both melons and acreage reserve as production possibilities results in an optimum program which includes cotton, cotton acreage reserve, barley, alfalfa seed, milo, and melons (Table 9). The 91 acres of cotton allotment placed in the reserve enterprise releases sufficient water from the cotton enterprise to permit all of the cropland to be utilized. The major expansion in acreage is in the barley and melon enterprises. Land, the cotton allotment, and water in March, June and the first part of July are the restricting resources.

Changing Assumptions With Respect to Soil Grades

Many farms in Western Fresno County have more than one soil grade. Thus the assumption of only one grade of soil will be relaxed and the effect on

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[1] The marginal value productivity of a limitational resource is the monetary value of an additional unit of that resource or the monetary loss resulting from the withdrawal of one unit of that resource from the optimum program.

TABLE 8

Optimum Farm Organization and Resource Utilization, Two Section Farm (2-1-M) On Soil Grade I, Western Fresno County, California

Resources			Enterprise organization				Unused resources	Value of the marginal unit of resource [a]	Total net cash return
item	unit	quantity available	barley	alfalfa seed	cotton	melons			
Soil grade I	acre	1,230	674	42	238	76	200	.00	
Irrigation water									
3/1 - 3/31	acre inch	3,984	3,032	0	952	0	0	9.00	
4/1 - 4/30	acre inch	3,840	3,032	167	0	0	641	.00	
5/1 - 5/31	acre inch	3,624	0	252	595	836	1,941	.00	
6/1 - 6/15	acre inch	1,752	0	418	595	418	321	.00	
6/16- 6/30	acre inch	1,608	0	0	1,190	418	0	21.50	
7/1 - 7/15	acre inch	1,608	0	418	1,190	0	0	6.80	
7/16- 7/31	acre inch	1,536	0	0	1,190	0	346	.00	
8/1 - 8/15	acre inch	1,440	0	0	1,190	0	250	.00	
8/16- 8/31	acre inch	1,536	0	0	1,190	0	346	.00	
Cotton allotment	acre	238	0	0	238	0	0	68.00	
Net cash return	dollar	---	27,470	2,840	58,290	9,010	---	---	97,610

[a] These are read as $9.00 per acre inch of water or $68.00 per acre of cotton allotment.

TABLE 9

Optimum Farm Organization and Resource Utilization, Two Section Farm (2-1-MR) on Soil Grade I, Western Fresno County, California

Resources			Enterprise organization								
item	unit	quantity available	cotton	barley	alfalfa seed	milo	melons	cotton acreage reserve	Unused resources	Value of the marginal unit of resource[a]	Total net cash return
Soil grade I	acre	1,230	147	755	52	58	127	91	0	10.70	
Irrigation water											
3/1 - 3/31	acre inch	3,984	588	3,396	0	0	0	0	0	6.70	
4/1 - 4/30	acre inch	3,840	0	3,396	208	0	0	0	236	.00	
5/1 - 5/31	acre inch	3,624	368	0	312	290	1,398	0	1,256	.00	
6/1 - 6/15	acre inch	1,752	368	0	520	165	699	0	0	4.80	
6/16- 6/30	acre inch	1,608	735	0	0	174	699	0	0	14.80	
7/1 - 7/15	acre inch	1,608	735	0	520	353	0	0	0	.90	
7/16- 7/31	acre inch	1,536	735	0	0	174	0	0	627	.00	
8/1 - 8/15	acre inch	1,440	735	0	0	174	0	0	531	.00	
Cotton allotment	acre	238	147	0	0	0	0	91	0	116.90	
Cotton acreage reserve	acre	119	0	0	0	0	0	91	28	.00	
Net cash return	dollar	---	36,000	30,770	3,510	4,290	15,050	11,620	---	---	101,240

[a] These are read as $10.70 per acre of grade I soil, $6.70 per acre inch of water or $116.00 per acre of cotton allotment.

optimum enterprise combinations investigated. Farms with two grades of soil are assumed to have 74 per cent of the 1,230 acres in soil grade I and 26 per cent in soil grade II. Farms with three grades of soil are assumed to be composed of 61 per cent soil grade I, 21 per cent soil grade II, and 18 per cent soil grade III.

The rest of the resources and production opportunities are assumed to remain the same as in the first sub-group of farms. [1]

Optimum organizations.--Changing the assumptions with respect to soil grade affects only the optimum enterprise combination on farms with both the melon and cotton acreage reserve enterprises available (Table 10). None of the other farm organizations change with the assumed change in soil grade. As the proportion of the poorer soils increases on the farms with melons and acreage reserve, the acres of cotton allotment "reserved" is decreased. This is primarily the result of a reduction in yields on poorer soils which makes it more profitable to use the limited quantity of water on the higher income crops produced on the better soils. The additional water required by the increased acreage of cotton results in a smaller acreage of other crops because of the reduction in available water during critical time periods. It is interesting to note that there are only 4 different optimum enterprise combinations for the 12 farm organizations considered.

The major effect of the decrease in the proportion of better soils is the reduction in net cash returns. The net cash return from optimum organization 2-1-S is approximately 4 per cent greater than organization 2-3-S and optimum organization 2-1-MR results in a 10 per cent greater net cash return than does organization 2-3-MR.

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[1] The optimum farm organizations and resource utilization resulting from the farms with two grades of soil is referred to throughout the study as the second sub-group of farms, and those resulting from the farms with three soil grades as the third sub-group of farms.

TABLE 10

Optimum Farm Organizations and Net Cash Returns for Two Section Farms with and without the Melon and Cotton Acreage Reserve Enterprises on One, Two, or Three Grades of Soil, Western Fresno County, California

Alternatives and crops produced	Unit	Acres of each crop selected and net cash returns for farms with:							
		one grade of soil	two grades of soil			three grades of soil			
		grade I	grade I	grade II	total	grade I	grade II	grade III	total
Farms without the melon enterprise		(2-1-S and R)	(2-2-S and R)			(2-3-S and R)			
Barley	acre	674	674	0	674	512	162	0	674
Milo	acre	70	3	67	70	0	70	0	70
Cotton	acre	238	238	0	238	238	0	0	238
Acreage reserve	acre	0	0	0	0	0	0	0	0
Idle land	acre	248	0	248	248	0	26	222	248
Net cash return	dollar	90,940	---	---	90,130	---	---	---	87,040
Farms with the melon enterprise									
Excluding the acreage reserve enterprise:		(2-1-M)	(2-2-M)			(2-3-M)			
Barley	acre	674	635	39	674	470	182	22	674
Alfalfa seed	acre	42	42	0	42	42	0	0	42
Melons	acre	76	0	76	76	0	76	0	76
Cotton	acre	238	238	0	238	238	0	0	238
Idle land	acre	200	0	200	200	0	0	200	200
Net cash return	dollar	97,610	---	---	95,840	---	---	---	92,450
Including the acreage reserve enterprise:		(2-1-MR)	(2-2-MR)			(2-3-MR)			
Barley	acre	755	614	98	712	470	182	22	674
Milo	acre	58	0	0	0	0	0	0	0
Alfalfa seed	acre	52	63	0	63	42	0	0	42
Melons	acre	127	0	115	115	0	76	0	76
Cotton	acre	147	195	0	195	238	0	0	238
Acreage reserve	acre	91	43	0	43	0	0	0	0
Idle land	acre	0	0	102	102	0	0	200	200
Net cash return	dollar	101,240	---	---	96,750	---	---	---	92,450

This analysis indicates that the availability of the melon enterprise increases net cash returns more than does participation in the acreage reserve program. Also that the proportions of soil grades may influence net cash returns more than participation in the reserve program. However, it is important to recognize that net cash returns can be increased in some instances by participating in the cotton acreage reserve program and that this requires no additional investment in land or crop production.

Marginal value productivity and resource utilization.--The marginal value productivity of a limitational resource is the monetary value of an additional unit of that resource or the monetary loss resulting from the withdrawal of one unit of that resource from the optimum program. 1/ Many of the resources that were considered as possible restrictions did not actually restrict the optimum program, i.e., not all of the resources available were used. The marginal value productivities of these resources are zero because the addition or subtraction of one unit has no effect on the optimum program.

Marginal value productivities are also useful in indicating the best possibilities available to the firm for further expansion of production by means of increasing the supply of certain limitational resources (Table 11). For example, in optimum organization 2-3-M an additional acre of grade I soil will increase net cash returns by $31.00, an acre of grade II soil by $12.25, and an additional acre of grade III soil will not increase net returns of organization 2-3-M. Thus, the farm firm would have an indication of which quality of land, if any, to obtain after taking into account the relevant cost of acquiring each resource.

1/ The marginal value productivity of a limitational resource is obtained from the simplex row in the final representation of the linear programming computations.

TABLE 11

Marginal Value Productivity of Resources for Two Section Farms with One, Two, or Three Grades of Soil and Various Assumptions with Respect to the Melon and Cotton Acreage Reserve Enterprises, Western Fresno County, California

Resource	Unit	Marginal value productivity of resource for (dollars):								
		standard farms			standard farms plus the melon enterprise			standard farms plus the melon and cotton acreage reserve enterprises		
		2-1-S and 2-1-R	2-2-S and 2-2-R	2-3-S and 2-3-R	2-1-M	2-2-M	2-3-M	2-1-MR	2-2-MR	2-3-MR
Soil grade I	acre	0	12.00	19.00	0	19.00	31.00	10.75	19.00	31.00
Soil grade II	acre	0	0	0	0	0	12.25	0	0	12.25
Soil grade III	acre	0	0	0	0	0	0	0	0	0
Irrigation water:										
3/1 - 3/31	acre inch	9.00	6.50	5.00	9.00	5.00	2.00	6.50	5.00	2.00
6/1 - 6/15	acre inch	0	0	0	0	0	0	4.75	3.00	0
6/16- 6/30	acre inch	0	0	0	21.50	19.00	16.75	14.75	16.00	16.75
7/1 - 7/15	acre inch	12.25	10.25	10.25	6.75	4.75	3.75	1.00	2.00	3.75
Cotton allotment	acre	147.00	155.00	155.00	67.00	87.00	103.00	117.00	109.00	103.00

Marginal value productivities of water are quite large in some time periods (more than $15.00 per acre inch). Water is a real restriction in the first half of July and the month of March for all farms. Considering marginal value productivities of water in one time period only, may not be very realistic if the farm firm has to make a large capital investment to obtain more water. A larger pump and/or motor,for example, would increase the supply of water in all time periods. Thus, the marginal valua productivity for an acre inch in one time period would understate the additional returns from obtaining more water. This would not be true, however, if water was available from a canal or reservoir.

The large marginal value productivities of the cotton allotment indicate the important place that cotton has in the farm organizations. An additional acre of cotton on the standard farms would increase net cash returns by approximately $150.00. 1/ Thus the other crops considered as production possibilities in this study could not compete favorably with the cotton enterprise for available resources if a larger allotment was available.

The marginal value productivities as obtained from the final representation do not convey enough information on which to base many important decisions. The major limitation of these value productivities is that they are associated only with one unit of the limitational resource without saying anything about the outcome from an increase in the supply of the resource of more than one unit. Moreover, these values have no practical implications unless the cost of acquiring the additional unit(s) of the resource is known. These problems are of a long-run nature and should be considered as such. Thus, when the

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1/ To increase cotton acreage by one acre, the farm operator must reduce the acreage of one or more crops in order to obtain the water required to produce the additional acre of cotton. In organization 2-1-S the operator would need to decrease the barley acreage by .89 acres and the milo acreage by .833 acres. Thus $98.00 would need to be subtracted from the $245.00 in order to obtain the additional net return from an acre of cotton.

expansion of the resource base is considered, a comparison of marginal value productivities is a starting point. However, in deciding which resource or resources it would be most profitable to expand, it is necessary to consider:

a) The relative magnitude of the marginal value productivities of the limitational resources;

b) The extent to which the supply of the particular resource(s) can be increased before another resource will cause a bottleneck in production (the marginal value productivities will change);[1] and

c) The cost and feasibility of acquiring more of the limiting resource.

The amount that the supply of a particular resource can be increased before its marginal value productivity changes was calculated (Table 12).[2] It is difficult to generalize about the quantity of land or water that can be added to the optimum organization without changing the marginal value productivities. However, in a number of instances a very substantial increase in the quantity of water would not change the marginal value productivities per acre inch of water. The contribution to the total net cash returns is a product of the marginal value productivity and the quantity of the resource that can be added. It does not always follow, though, that the resource with the highest marginal product (assuming the same unit cost) will be the best

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[1] The marginal value productivities in the final representation remain the same as long as the change in the supply of one of the resources does not force one of the entries in the z-c row in the final representation to equal zero.

[2] This is done by calculating the ratios of the entries in the P_0 column (the column representing the inventory in the resources and active processes in the optimum program) to the corresponding negative coefficients in the j^{th} column representing the i^{th} limitational resource in consideration ($j = 1, 2, \ldots, n$; $i = 1, 2, \ldots, m$; $m < n$). The smallest ratio points out to the first bottleneck which is expected to limit the expansion by the addition of more units of this resource. The magnitude of the ratio represents the quantities of the resource that can be added to the optimum program before another bottleneck is approached.

Whenever the smallest ratio is a ratio of the acreage of a productive process to a coefficient, and not a resource to a coefficient, it indicates that with an increase in the supply of the i^{th} resource, a certain process in the optimum program will reach a zero level before any resource.

TABLE 12

Quantities of Limitational Resources That Can be Added to the Optimum Farm Organizations Without Changing the Marginal Value Productivities, Two Section Farms, Western Fresno County, California

Resource	Unit	Quantities of limitational resources								
		standard farms			standard farms plus the melon enterprise			standard farms plus the melon and cotton acreage reserve enterprises		
		2-1-S and 2-1-R	2-2-S and 2-2-R	2-3-S and 2-3-R	2-1-M	2-2-M	2-3-M	2-1-MR	2-2-MR	2-3-MR
Soil grade I	acre	---	66	162	---	39	22	---	98	22
Soil grade II	acre	---	---	---	---	---	22	---	---	22
Soil grade III	acre	---	---	---	---	---	---	---	---	---
Irrigation water:										
3/1 - 3/31	acre inch	808	14	120	641	641	641	348	384	641
6/1 - 6/15	acre inch	---	---	---	---	---	---	333	48	---
6/16- 6/30	acre inch	---	---	---	321	321	321	655	84	321
7/1 - 7/15	acre inch	82	82	82	321	321	321	994	84	321
Cotton allotment	acre	16	16	16	50	50	17	102	76	17

choice to develop extensively. In certain cases it might be more profitable to increase the supply of the resource with the greater marginal value productivity to the limit, and then to expand the resource with the smaller marginal value.

Changing Assumptions with Respect to Cotton Acreage Reserve

The cotton acreage reserve program is subject to a considerable amount of legislative change. Prices paid for reserving cotton acreage and the quantity of land that can be reserved are the major types of changes to be expected. In 1958 a restriction was placed on the quantity of cotton allotment that a farm could put into the cotton acreage reserve. This restriction was in the form of a $3,000 maximum that a farm could receive for reserving cotton acreage. Under the assumed price received for reserving cotton allotment this would restrict the farm to approximately 23 acres of cotton allotment that could be reserved. The optimum farm organization for the farm with one grade of soil and the melon enterprise would include barley, melons, alfalfa seed, cotton, and 23 acres of cotton acreage reserve. This would result in a net cash return of $99,000 or an increase of $1,400 over the farm that excluded the cotton acreage reserve enterprise as a production possibility. However, if the farm operator was also required to take 23 acres of another crop out of production in order to compensate for the 23 acres of cotton reserve the net cash return would only be $500 greater than the farm without the reserve enterprise. 1/ As the proportion of the better soils decreases the difference becomes even smaller. Thus it would appear that the restriction placed on cotton acreage reserve for the 1958 crop year would discourage the farm operators, under the assumed relationships, from placing part of their cotton allotment in the cotton acreage reserve program.

1/ This is assuming that the farmer is prohibited from planting more than a base number of acres of crops other than legumes.

Five Section Farms

The five section farms have 3,100 acres of land suitable for intensive agricultural production, an assumed seasonal distribution of water, and certain production opportunities, some of which are institutionally limited (see Section II). The five section farms have approximately 2.5 times as much land, water, and cotton allotment available as do the two section farms. 1/ The major difference between the two and the five section farms is that the net cash returns from the various production possibilities are higher for the larger farms. This is a result of the somewhat lower production costs on these farms.

Optimum farm organizations and net cash returns for the two section farms with and without the melon and cotton acreage enterprises and on one, two and three grades of soil are presented in Table 13. These optimum organizations are approximately linear multiples of the optimum organizations for the two section farms. 2/ The same relationship among farm organizations with respect to net cash returns prevails. The standard farms have the lowest net cash returns and the standard farms with the melon and acreage reserve enterprises have the highest net cash returns. Many of these optimum organizations result in a net cash return in excess of one quarter of a million dollars.

Marginal value productivities and the per cent that the limitational resources can vary before their marginal value productivities change are similar for the two and five section farms. The interpretations that

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1/ It is only approximate because it is assumed that 4 per cent of the total land resource on the two section farm is devoted to roads, fences and farmstead, whereas on the five section farm only 3 per cent is used for these purposes.

2/ Ibid.

TABLE 13

Optimum Farm Organizations and Net Cash Returns for Five Section Farms with and without the Melon and Cotton Acreage Enterprises on One, Two, or Three Grades of Soil, Western Fresno County, California

Alternatives and crops produced	Unit	Acres of each crop selected and net cash returns for farms with:							
		one grade of soil	two grades of soil			three grades of soil			
		grade I	grade I	grade II	total	grade I	grade II	grade III	total
Farms without the melon enterprise		(5-1-S and R)	(5-2-S and R)			(5-3-S and R)			
Barley	acre	1,684	1,684	0	1,684	1,295	389	0	1,684
Milo	acre	173	26	147	173	0	173	0	173
Cotton	acre	596	596	0	596	596	0	0	596
Acreage reserve	acre	0	0	0	0	0	0	0	0
Idle land	acre	647	0	647	647	0	89	558	647
Net cash return	dollar	244,460	---	---	242,660	---	---	---	234,740
Farms with the melon enterprise									
Excluding the acreage reserve enterprise:		(5-1-M)	(5-2-M)			(5-3-M)			
Barley	acre	1,684	1,606	78	1,684	1,191	462	31	1,684
Alfalfa seed	acre	104	104	0	104	104	0	0	104
Melons	acre	189	0	189	189	0	189	0	0
Cotton	acre	596	596	0	596	596	0	0	596
Idle land	acre	527	0	527	527	0	0	527	527
Net cash return	dollar	260,510	---	---	256,450	---	---	---	247,960
Including the acreage reserve enterprise:		(5-1-MR)	(5-2-MR)			(5-3-MR)			
Barley	acre	1,896	1,552	228	1,780	1,191	462	31	1,684
Milo	acre	160	0	0	0	0	0	0	0
Alfalfa seed	acre	128	158	0	158	104	0	0	104
Melons	acre	320	0	287	287	0	189	0	189
Cotton	acre	356	488	0	488	596	0	0	596
Acreage reserve	acre	240	108	0	108	0	0	0	0
Idle land	acre	0	0	279	279	0	0	527	527
Net cash return	dollar	270,540	---	---	258,680	---	---	---	247,960

were made for the smaller farms are also applicable to the larger farms. Therefore, tables containing the marginal value productivities for the five section farms are not included.

If the larger farms are linear multiples of the two section farms, with only minor differences, then the basic analysis presented in this manuscript would be applicable to more than 70 per cent of the farms in Western Fresno County.

Discussion of Optimum Organizations

The optimum programs selected for the two and five section farms are valid only if the assumptions about resource availability, prices, and technical coefficients are valid. However, it was demonstrated that when the assumptions concerning soil grade (resource availability) were changed the optimum programs were not greatly altered in most instances. Thus, it appears that the optimum combination of enterprises is not greatly affected by soil grade if there is a sufficient quantity of grade I soil to produce crops requiring allotments. Of course, the larger the proportion of more productive soil the larger the net returns.

Net returns are affected by (1) the quality of the soils and (2) by the alternatives available to the farm operation. A decrease in the quality of soil decreases net returns considerably. However, the alternatives available to the farm operation, primarily melons, has a greater impact upon net returns than the changes in soil quality which were considered. On farms without the melon enterprise available the cotton acreage reserve enterprise did not enter into the optimum combination of enterprises. However, the optimum organizations with both the melon and the cotton acreage reserve enterprises available had the highest net return of any of the organizations considered.

Several optimum organizations, not presented in this manuscript, were computed with sugar beets considered as a production possibility in order to further investigate the importance of specialty crops in the farm organization. The sugar beet enterprise was included in all of these optimum organizations. In fact, when both sugar beets and melons were considered as available enterprises not all of the cotton allotment was used. 1/ This, then, is another indication that farm operators in this area should investigate the possibility of producing certain of the specialty crops.

In the event that the farm operator decides to expand the size of his operation the marginal value productivities are helpful in indicating which resources would increase net returns the most. Obtaining more land or more water are the two major alternatives. Not very much can be said about the relative profitability of obtaining the different limiting resources unless the costs of obtaining the additional resources are known.

In no instance can any of the farms use additional grade III soil and in only two instances would net cash returns have been increased if additional grade II soil had been available. Farms with three grades of soil and the melon enterprise can afford to pay up to $31.00 per acre annually for additional grade I soil and $12.25 for grade II soil. The farms without the melon enterprise or farms with two grades of soil, in most instances, can afford to pay up to $19.00 per acre annually for grade I soil. This is assuming that the additional land is adjacent and can be irrigated from the present wells. Additional cotton allotment will increase net cash returns by approximately $150.00 per acre on farms without the melon enterprise and between $67.00 and $117.00 on farms with the melon enterprise.

1/ It was assumed that a sugar beet allotment of 250 acres was available to the farm operator. The major reason that sugar beets and melons replaced some of the cotton allotment was the timing of water demand.

The returns from additional irrigation water are very high in certain time periods. This implies that net returns can be increased if water is conserved, stored, and/or applied at different times. Careful use of water is a definite possibility for increasing net returns. Applying water a little earlier or later in some instances, e.g., in the end of February or the early part of April, can also be profitable if this does not decrease crop yields more than returns are increased.

In this investigation, it was assumed that the number of wells per farm and the size of the pumping plant did not change between 1953 and the present time. However, a considerable drop in the pumping depth was assumed which reduced the quantity of water that could be pumped in any given time period. Recent information has indicated that many of the farm operators in this area have increased the quantity of water available by the installation of a larger pumping plant or by the drilling of additional wells. The investment in a new well and pumping plant may be as high as $30,000 or more and the installation of a new pumping plant may cost $10,000 to $20,000 or more depending upon the depth of the well, the size of the pumping plant, etc. This is a large outlay but the returns from additional water are also quite large. The analysis indicated that the quantity of water could be increased approximately 20 per cent for the two section farm with melons without changing the marginal value productivities (Table 12). Therefore, a 20 per cent increase in the available water for each time period was assumed. This increased the net cash returns on the two section farm with melons and one grade of soil by approximately $13,500. 1/ The net cash return on the farms with two and three grades of soil were increased by approximately $10,800 and

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1/ This assumes that the variable cost per acre inch of water does not increase.

$7,850, respectively. The increase in net returns for the farms without melons was somewhat smaller. If the water supply were increased by one-third (the equivalent of adding a well and pumping plant of the same size as those already on the two section farm) the net cash return for the farm with melons and one soil grade would be increased by $19,000 per year. Thus, even if a new well and pumping plant or just a new pumping plant has a life expectancy of only five years it appears that it would be a profitable investment. However, in making a decision concerning this type of investment the farm operator must consider the additional equipment, if any, that is required for the crops, the falling water table and its effects upon pumping costs and the additional investment, if any, in the distribution system.

Increasing the available water supply by 20 per cent and 33 per cent did not change the enterprises appearing in the optimum program. The effect of increasing quantity of water available was to reduce the quantity of idle land to zero or practically zero and increase the acreages of the crops other than cotton.

V. STABILITY OF THE OPTIMUM ENTERPRISE COMBINATIONS

The farm organizations presented in the previous section are optimum organizations for the assumed resource base, technical coefficients of production, and factor and product prices. A question then arises as to how much can the product and factor prices or yields change before these organizations are nonoptimum. One is much more confident making statements or decisions regarding a production program that is stable (not very sensitive to price and yield changes) than one that is relatively unstable (very sensitive to price and yield changes). Certain factors for which assumptions were made, i.e., product prices and yields, may vary considerably from year to year. Although the choice of an optimum program, under the control of the farm operator, is a subjective choice it can be made with more confidence by improving the knowledge regarding the sensitivity of the program considered.

Changes in the supply of certain resources, on the other hand, can intentionally be planned by the farm operator with more certainty. Generally, such changes have the characteristics of longer run problems. However, once the change in the supply of limitational resource has taken place, the allocation problem is a short-run problem, the outcome of which is subject to price or yield variations.

The first type of variations affect the net cash returns from a unit level of a process whereas changes of the second type affect the level of the process.

Stability boundaries and the effects of changing the supply of certain limitational resources, i.e., the cotton allotment and the water supply, on optimum enterprise organizations are examined in this section.

Stability with Respect to Variations in Net Cash Returns

The linear programming technique selects the enterprises to be included in the optimum organization and determines the level at which they are

produced on the basis of the relative net cash returns that each process can yield per unit of limitational resource. Therefore, variations in the net cash returns from an individual process change the net return-productivity ratios, and thus the relative profitability of the various processes with respect to each other. Usually, however, there is a range within which these net cash returns may change without affecting the enterprise organization.

The assumptions regarding the physical coefficients of production, product prices, and factor costs are basic in the determination of net cash returns from individual processes and the farm as a whole. Since net cash return is a function of these three factors, the range within which it can vary before the optimum combination of enterprises change will be determined first. The amount of variability can then be expressed in terms of changes in prices, costs, or physical coefficients of production.

Using the optimum enterprise organization as obtained from the final representation of the simplex method of calculation, limits can be determined within which net cash returns can vary without changing the optimum organizations. 1/ This assumes that everything else remains constant except net cash returns from the one or two processes being considered.

1/ An optimum solution determined by means of linear programming procedure is characterized by a positive z_j-c_j row in the final representation. Each individual entry in this row is calculated by summing up the products of the coefficients in the j^{th} column and corresponding nonzero entries in the c_j column, and subtracting this from the entry in the c_j row of the original table.

To determine the limits within which the net cash return from the i^{th} process in the optimum program can change without changing the optimum program, it is necessary to determine the net cash returns from the i^{th} process that will force each of the nonzero z_j-c_j's in the final representation to equal zero. (Footnote continued on the next page.)

The limits within which net cash returns can vary without changing the optimum enterprise combination are presented in Table 14 for each crop entering into the optimum organization on the farms with one grade of soil. These limits are constructed under the assumption that the net cash return for all of the crops, other than the one being considered, remain the same as in the original programs. Thus the net returns from barley on the farm without melons and cotton acreage reserve can vary between zero and $206.20 without changing the optimum organization provided the net returns for all of the other crops remain the same as in the original program. The limits are quite wide for most of the crops with milo having the narrowest limits. The optimum organizations that exclude the cotton acreage reserve are more stable than

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1/ (continued from previous page) Let a_{ij} be the coefficient in the i^{th} row and the j^{th} column, k_{ij} the unknown constant in the final representation, and c_i the net cash return from the i^{th} process which must be changed in order to force the corresponding z_j-c_j to zero. A set of equations can be formed for the i^{th} productive process, each in the form of $k_{ij}(a_{ij}) = z_j-c_j$. Since a_{ij} and z_j-c_j are known, it is only necessary to solve for k_{ij}. There will be at least one positive and one negative k_{ij} obtained for the i^{th} process. The smallest positive k_{ij} indicates the amount that net cash returns from the i^{th} process can be decreased and the smallest negative k_{ij} indicates the amount that net cash returns can increase before the optimum program will change. To determine stability boundaries for two processes, the i^{th} and the x^{th} processes, the same calculations need to be computed for each process. Thus assuming that everything else remains unchanged net cash return from the i^{th} productive process can vary between $c_j-(-k_{ij})$ and $c_j-(+k_{ij})$ without changing the optimum enterprise organization.

To determine the stability boundary lines it is necessary to select another process, the x^{th} process. A new value is assigned to the x^{th} process and new z_j-c_j's are calculated. Using the new z_j-c_j's another set of k's, k'_{ij}'s are determined. A straight line is drawn between k_{ij} and k'_{ij}. This is repeated for all of the column vectors having nonzero z_j-c_j's.

The same process is repeated for the x^{th} process, first determining k_{xj} and then k'_{xj} where the value of the i^{th} process is changed to compute k'_{xj}. The most restrictive of these boundary lines form the stability boundaries for the i^{th} process and the x^{th} process.

The limits within which each return can vary without changing the optimum enterprise combination are presented in Table 11. The [illegible] and [illegible] on the farm [illegible] each of [illegible] that the [illegible] for [illegible] of the [illegible] that the remaining [illegible] remain the same as [illegible]. Thus the net returns from barley on the [illegible] and [illegible] can vary between [illegible] and [illegible] without changing the optimum combination provided the net returns for all other crops remain the same as in the original program. The limits are quite [illegible] of the crop with [illegible] the narrowest limits. The [illegible] that [illegible] situation [illegible] and [illegible]

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[11] continued from previous page: [illegible] a_{ij} is the coefficient in the i^{th} row and the j^{th} column, z_j the unknown [illegible] in the final [illegible] and c_j the net cash return from the j^{th} process which must be reduced in order to force the corresponding $z_j - c_j$ to zero. A set of equations can be formed for the i^{th} productive process, each in the form of [illegible]. Since a_{ij} and $z_j - c_j$ are known, it is only necessary to solve for k_{ij}. There will be at least one positive and one negative k_{ij} obtained for the i^{th} process. The smallest positive k_{ij} indicates the amount that the net return from the i^{th} process can be [illegible] and the smallest negative k_{ij} indicates the amount that net cash returns can increase before the optimum program will change. To determine stability boundaries for two processes, the i^{th} and the k^{th} processes, the same calculations need to be repeated for each [illegible]. Thus assuming that everything else remains unchanged net cash returns from the i^{th} productive process can vary between [illegible] and $c_i(+k_{ij})$ without changing the optimum enterprise combination.

To determine the stability boundary lines it is necessary to select another process, the k^{th} process. A new value is assigned to the i^{th} process and new $z_j - c_j$'s are calculated. Using the new $z_j - c_j$'s and the a_{kj}'s, k'_{kj}'s are determined. A straight line is drawn between [illegible] and [illegible]. [illegible] for all of the columns [illegible] negative $z_j - c_j$'s.

The same process is repeated for the k^{th} process. [illegible] k'_{ij} where the value of the i^{th} process is changed by [illegible]. The area [illegible] of these boundary lines form the stability boundaries for the i^{th} process and the k^{th} process.

TABLE 14

Limits Within Which Net Cash Returns Can Vary Without Changing the Optimum Enterprise Combinations by Crops for Two Section Farms, One Soil Grade, With and Without the Melon and Cotton Acreage Enterprises, Western Fresno County, California [a]

Farming operations by alternative enterprises considered available	Limits within which net cash returns can vary by enterprises (dollars)					
	alfalfa seed	barley	cotton	cotton acreage reserve	melons	milo
Net cash returns used in obtaining optimum enterprise combinations	67.50	40.76	244.92	127.68	118.52	73.98
Farms without the melon enterprise						
Excluding the acreage reserve enterprise (2-1-S):						
Lower limit	---[b]	0	97.90	---	---	40.50
Upper limit	---	206.20	[c]	---	---	250.40
Including the acreage reserve enterprise (2-1-R):						
Lower limit	---	0	255.60	---	---	40.50
Upper limit	---	62.50	[c]	---	---	97.20
Farms with the melon enterprise						
Excluding the acreage reserve enterprise (2-1-M):						
Lower limit	15.60	0	177.70	---	61.40	---
Upper limit	201.90	116.40	[c]	---	192.40	---
Including the acreage reserve enterprise (2-1-MR):						
Lower limit	19.40	15.10	219.90	104.90	62.50	66.30
Upper limit	168.40	68.90	267.70	152.70	127.80	101.30

(continued on next page.)

Table 14 continued.

a/ This assumes that the net cash returns for all enterprises, except the enterprise under consideration, remains at the level originally assumed in obtaining the optimum enterprise combinations.

b/ Dashes indicate that the enterprise did not enter into the optimum enterprise combination under consideration.

c/ Infinity.

those that include this enterprise. It appears that the optimum organizations are relatively stable with the possible exception of the organizations including both the melon and the cotton acreage reserve enterprises.

The limits within which net cash returns can vary without changing the optimum enterprise combinations are narrower for farms with two and three grades of soil. In most instances this is not actually due to a change in the crops or the number of acres of each crop included in the optimum organization but rather it is a result of crops shifting from one grade of soil to another. Thus, for example, as the net cash return from melons is increased the entire acreage of melons may shift to soil grade I and an equal acreage of barley may shift to soil grade II. The net result is that the same acreage of each crop is produced but the distribution of crops on the various soil grades is somewhat different.

In many instances it is useful to know the amount that net cash returns can vary for two enterprises simultaneously without changing the optimum enterprise organization. In order to do this it is necessary to construct stability boundaries. 1/ It is assumed in determining the optimum programs that net cash return from an acre of cotton and an acre of melons on soil grade I is $244.92 and $118.52, respectively. Assuming that net cash returns from the other crops do not change, any combination of net cash returns from these two enterprises that fall within the stability boundaries (Figure 5) will result in the same optimum organization (2-1-M). Thus the optimum organization does not change even if the net cash return from an acre of melons decreases

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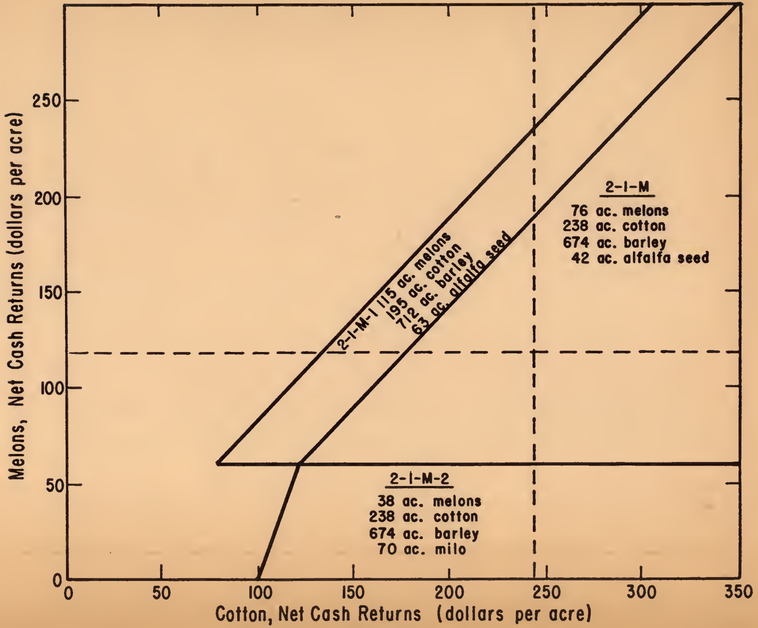
1/ See footnote 1 page 48 for the method used to calculate the stability boundaries.

Figure 5. Stability Boundaries for Optimum Organizations With Respect to Changes in Net Cash Returns from Melons and Cotton, Two Section Farm With Melons and One Soil Grade



to approximately $61.00 and that of cotton to approximately $125.00, or if the net cash returns from these enterprises increase to $250.00 and $300.00, respectively.

Many times the stability boundaries are quite narrow, that is, a relatively small change in net cash returns would result in a different optimum organization. When this occurs several optimum programs and their stability boundaries can be determined for various assumptions with respect to the net cash returns from the two enterprises. This will result in a price map such as that presented in Figure 5. If the combination of net cash returns from cotton and melons is such that it falls slightly above the stability boundaries for organization 2-1-M, e.g., the net cash returns from the cotton and melon enterprises are $200.00 and $150.00, respectively, then organization 2-1-M-1 would be the optimum organization.

A price map was also constructed for melons and alfalfa seed on the two section farm 2-1-M (Figure 6). The optimum organizations directly above (2-1-M-1) and the optimum organizations directly below (2-1-M-2) the optimum combination of enterprises selected under the original assumptions (2-1-M) are identical in Figure 5 and Figure 6.

The price map for cotton and cotton acreage reserve for the farm with one grade of soil and the melon and cotton acreage reserve enterprise (2-1-MR) is presented in Figure 7. The optimum organizations 2-1-MR-3 and 2-1-MR-4 are the same as the optimum organizations for the farms with two grades of soil (2-2-MR) and three grades of soil (2-3-MR), respectively. This can be interpreted as meaning that the decrease in net cash returns of cotton acreage reserve relative to cotton has the same effect as decreasing the proportion of better soils available to the farm operator.

Figure 6. Stability Boundaries for Optimum Organizations With Respect to Changes in Net Cash Returns from Melons and Alfalfa Seed, Two Section Farm With Melons and One Soil Grade

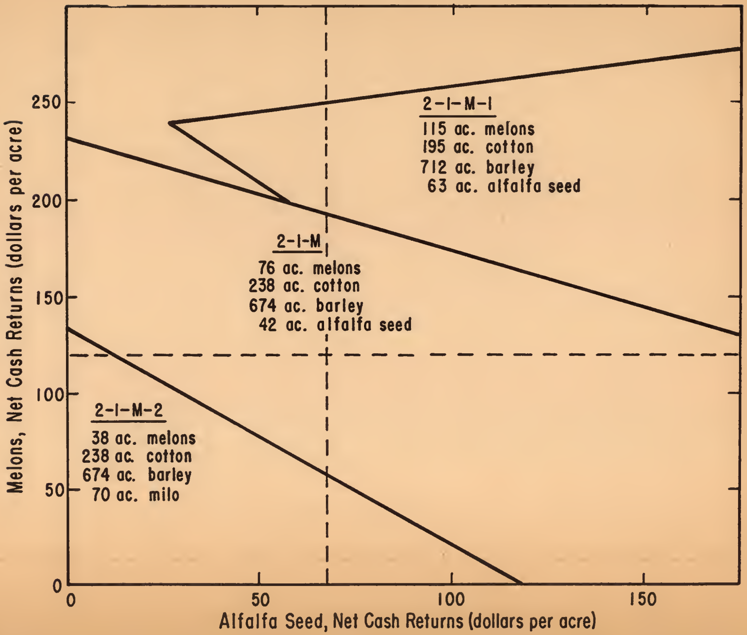
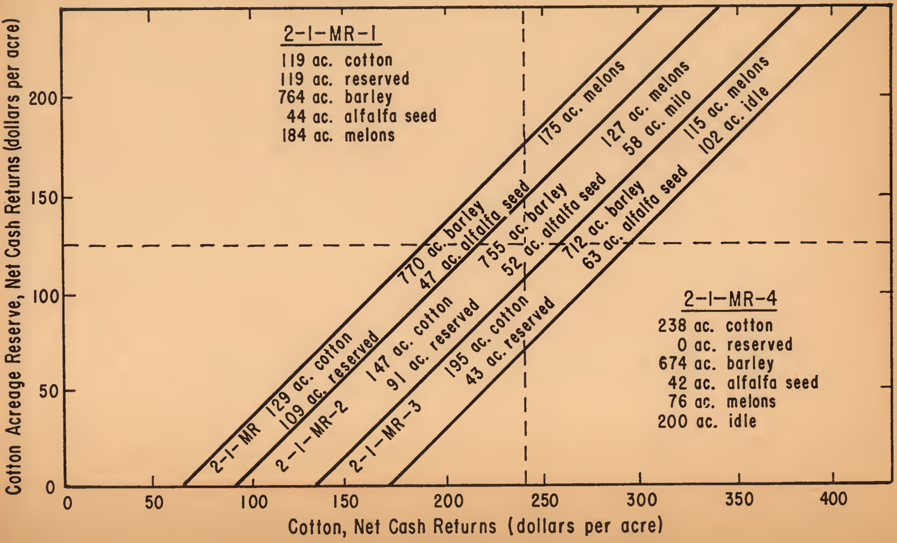


Figure 7. Stability Boundaries for Optimum Organizations With Respect to Changes in Net Cash Returns from Cotton and Cotton Acreage Reserve, Two Section Farm With Melons, Cotton Acreage Reserve and One Soil Grade



Stability with Respect to Variations in Yields and Prices

The limits within which crop yield, product prices or factor prices can vary without changing the optimum enterprise organization are determined quite easily from the stability limits presented in terms of net cash returns. In optimum organization 2-1-M (Figure 5) the net cash return from cotton can vary between \$177.70 and infinity per acre without changing the optimum organization when the net cash return from melons is \$118.52 per acre. Expressed in terms of prices, assuming a 1,125 pound yield of lint per acre for cotton, the price per pound can decrease approximately \$.06 without changing the optimum program. Also assuming these same conditions the yield can decrease by more than two-fifths of a bale per acre without changing the optimum program. 1/ Conversely, assuming the original net cash return from cotton the price of melons can vary between \$2.78 and \$3.52 per crate and the yields can vary between approximately 130 crates and 230 crates without changing the optimum organization. The above is another indication of the stability of these optimum programs in that the average prices received for melons and cotton have been within these limits in recent years.

Stability boundaries can also be constructed for prices and yields of the various crops. However, it does not appear necessary to compute these boundaries at this time.

Changes in the Cotton Allotment and Water Availability

The constraint imposed by the cotton acreage allotment was the basic reason for instigating this research. As the possibility of having the cotton acreage allotment increased, decreased, or even removed exists it is

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1/ The limits for yields are somewhat more difficult to calculate because the differences in harvesting costs must be taken into consideration.

important to determine the effects on the optimum enterprise organizations.[1] The parametric linear programming technique is used to analyze this problem.[2] This technique is essentially that of allowing a restriction in the production program to vary up to a point where another resource becomes limitational or up to a point where another resource is in excess supply. Any further change in the restriction will require the replacement of one process (disposal or productive) by another process. This procedure is continued until the limitational resource in question (the cotton allotment) becomes in excess supply.

Parametric linear programming was used in analyzing the effect of removing controls on the acreage of cotton that may be produced by the two section farms (Table 15).[3] If the controls on cotton acreage were removed, the analysis indicates that cotton acreage would increase by very little. This small increase in the cotton acreage is a result of the scarcity of water during certain critical time periods.

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[1] Congress has approved a measure for the 1959 and 1960 crop years that would permit farm operators to increase their cotton acreage by as much as 40 per cent above their cotton allotments for these years. This will probably result in an increase of about 30 per cent per farm over the 1958 cotton acreage that could be planted. However, the support price for cotton for those farmers increasing their cotton acreage will be 15 parity points below the support price received by those not exceeding their 1959 or 1960 allotments.

[2] For the complete calculation procedure see Boles, J. N., Parametric Linear Programming Computations, Department of Agricultural Economics, University of California, Berkeley, California, January 1957, 17p. (Processed).

[3] In making the changes in the final representation of organization 2-1-MR, the G vector was defined as $G = (P_{42} + \frac{1}{2}P_{44})$, where P_{42} is the column vector of cotton acreage allotment in the final representation, and P_{44} is the column vector of the cotton acreage reserve. That implies that an increase or a decrease of one acre in cotton acreage allotment is associated with an increase or a decrease of $\frac{1}{2}$ acre in the cotton acreage that can be reserved.

TABLE 15

Effects on Optimum Organizations of Increasing Cotton Acreage and Available Water, Two Section Farm, Soil Grade I, Western Fresno County, California

Alternatives and crops produced	Unit	Farm with two wells		Farm with three wells a/	
		with a 238 acre cotton allotment	no restriction on size of cotton allotment	with a 238 acre cotton allotment	no restriction on size of cotton allotment
Farms without the melon enterprise		(2-1-S)			
Alfalfa seed	acre	0	17	0	25
Barley	acre	674	629	788	773
Cotton	acre	238	288	238	432
Milo	acre	70	0	204	0
Idle land	acre	248	386	0	0
Net cash return	dollar	90,940	97,320	105,500	139,000
Farms with the melon enterprise		(2-1-M)			
Alfalfa seed	acre	42	17	81	25
Barley	acre	674	629	689	727
Cotton	acre	238	288	238	432
Melons	acre	76	31	222	46
Idle land	acre	200	0	0	0
Net cash return	dollar	97,610	100,940	116,600	142,580

a/ It is assumed that the addition of the third well increases the water available in all time periods by 50 per cent.

The effect on net cash return of adding another well to the two section farm has been mentioned earlier. However, the effect of increasing both the water availability and the size of the cotton allotment is presented in Table 15. The simultaneous increase of 50 per cent in the quantity of water available and the removal of the restriction on the quantity of cotton that can be produced has a much greater effect on net cash returns than does a change in either one or the other but not both. As the quantity of water is increased within the ranges indicated here, the incentive for farm operators to obtain more cotton acreage is undoubtedly increased.

It is recognized that any substantial increase in the cotton allotments will be accompanied by a decrease in the price received for cotton. This analysis indicates that farm operators on the two section farms and three wells would be willing to take a much larger reduction in the price of cotton in order to have the allotments increased than the farm operators with only two wells. However, additional information on the costs involved needs to be obtained before the exact magnitude of the price reductions can be determined.

SUMMARY AND CONCLUSIONS

The cotton acreage allotments imposed in 1954 required cotton producers to reduce their cotton acreage in order to continue to receive price supports at relatively high levels. In Western Fresno County, the cotton acreage was reduced by 45 per cent between 1953 and 1956. This reduction in the acreage of cotton, the crop which provides the largest single source of agricultural income in the area, released considerable quantities of resources, e.g., land, machinery, equipment, water, etc. Thus since 1954 the cotton growers in Western Fresno County have been confronted with the problem of determining the next most profitable use of these available resources.

This study undertook to investigate the adjustment possibilities available to the cotton farms in the area, and to determine the optimum enterprise combinations and resource allocation for representative cotton farms under varying conditions with respect to resource availability, yields and prices. Special consideration is given to the availability of certain resources, e.g., variations in the quality of the land resource, a specialty crop represented by melons, cotton acreage reserve, and the cotton acreage allotment.

At a point in time, when the farm is operating within a set of restrictions, the problem of resource allocation is a short-run problem. Linear programming is a useful technique for analyzing such short-run allocation problems. Parametric linear programming is useful in investigating a change in one or more of the restrictions.

To obtain the framework of analysis, the physical, economic, and institutional environments of the cotton farms in Western Fresno County were investigated and defined. The physical environments in Western Fresno County are favorable to the production of most of the summer and winter irrigated field crops. Seventy per cent of the total area is suitable for intensive agricultural production. Large cotton farms are dominant in number and

acreage of cropland in Western Fresno County. It appears that the large size of farms in the area is due to the unique physical and economic environment. A two section farm and a five section farm were synthesized on the basis of interviews of a stratified sample of farms in the area.

Interviews with farmers and other sources provided information on technical coefficients of production. This information was synthesized into standards of input-output relationships (processes) for the crops commonly produced in the area. Budgets were also constructed for these crops.

Four basic production alternatives were considered on each farm size: "standard farm"--farm with cotton, "standard farm with melons," "standard farm plus cotton acreage reserve," and "standard farm plus melons and cotton acreage reserve." Using the linear programming technique, optimum production programs were determined for the four basic alternatives on three different soil grade combinations.

The following are the major findings of this investigation.

Both the production alternatives and the quality of soil available to the farm operator have quite a large impact on net cash returns. However, in many instances, a change in the proportion that the better soils are of the total land base had no effect upon the optimum organization of enterprises. The cotton acreage reserve enterprise did not enter the optimum enterprise organization unless a specialty crop such as melons was available to the farm operator. This is because of the relatively high net cash return from melons per unit of water in certain months plus the fact that melons do not use any water in several of these critical time periods. When melons were considered as a possible production alternative, they were always included in the optimum enterprise. This indicates that specialty crops such as melons, sugar beets, seed crops, etc., are strong competitors for the resources released from the cotton enterprise because of the reduction in the size of cotton allotments.

The quantity of irrigation water available in certain time periods and the acres of cotton allotment were the major limiting resources. The analysis indicated that the returns from additional water or acres of cotton allotment would be quite high. On all of the optimum farm organizations an additional acre inch of water, during one of the time periods in which all of the available water was used, would have increased net cash returns by more than $10.00. An additional acre of cotton allotment would have increased net cash returns by more than $100.00, in most instances. Therefore, ways to increase the quantity of water available during certain time periods or the possibility of obtaining a larger cotton allotment deserve careful consideration by the farm operator.

The optimum farm organizations are optimum for the assumed resource base, technical coefficients of production, and factor and product prices. The question then arises concerning what happens when the above change. In order to answer this question limits within which yields, product prices and costs could vary without changing the optimum enterprise combinations were constructed for several of the optimum programs. These limits were first expressed in terms of allowable variations in net cash returns and then translated into variations in yields, prices and costs. Generally the limits within which net cash returns (and thus yields, prices and costs) could vary without changing the optimum organization were quite large. In fact, the average prices for most of the commodities in recent years were within these limits for those optimum organizations investigated. This indicates that the optimum organizations are relatively stable and are not likely to change with small deviations in prices, costs, or yields.

The limits within which the restricting resources could vary without changing the return from each additional unit were determined. These limits

indicate that for some of the optimum organizations a very substantial increase in the quantity of water would not change the return per acre inch of additional water if it were available.

When the restriction on the quantity of cotton that could be produced was removed, the optimum organization for the two section farms included 288 acres of cotton, an increase of 50 acres over the cotton allotment assumed throughout this investigation. This small increase in the quantity of cotton produced was a result of the water limitation. However, when the available water supply was increased by 50 per cent (the equivalent of adding another well) and restrictions were removed from the quantity of cotton that could be produced the optimum organization for the two section farms included 432 acres of cotton. The effect on net cash returns of increasing the available water by 50 per cent, even without increasing the size of the cotton allotment, was very significant. Net cash returns on the farm with one soil grade and melons were increased by $19,000 with this increase in the water supply. However, only the variable costs are included in this figure of $19,000. The cost of installing a new well and/or pumping plant must also be taken into consideration before a conclusion can be reached concerning the profitability of obtaining additional water.

The supply of water, the size of the cotton allotment, the alternative crops available to the farm operator, and the grade of soil are all important in influencing the net cash return. For many of the farm organizations a change in these factors did not result in a change in the optimum combination of enterprises. Thus the enterprises entering into the optimum combination were relatively stable although the level at which they were produced (the number of acres) did vary quite drastically.